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Evaluation of Dual Simultaneous Instrument Landing System Approaches to Runways Spaced 3000 Feet Apart with One Localizer Offset Using a Precision Runway Monitor System

Richard E. Ozmore, ACT-510
Sherri L. Morrow, SRC

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16. Abstract

A real-time simulation was conducted to evaluate simultaneous ILS approaches to two runways spaced 3000 ft apart with one localizer offset by 2.5 degrees. Air traffic controllers monitored traffic using a simulated Precision Runway Monitor (PRM) system, which consisted of Final Monitor Aid (FMA) displays and a simulated radar update rate of 1.0 second.

Aircraft blunders were introduced to test the air traffic control system ability to maintain adequate separation between aircraft on final approaches during critical situations using the proposed runway configuration. Four criteria were developed by the Multiple Parallel Approach Program (MPAP) Technical Work Group (TWG) to evaluate the study: 1) the number of Test Criterion Violations (TCVs) relative to the total number of at-risk, non-responding blunders, and relative to a predetermined target level of safety of no more than one fatal accident per 25,000,000 approaches; 2) the frequency of No Transgression Zone (NTZ) entries and nuisance breakouts (NBOs); 3) an evaluation of controller communications workload; and 4) an operational assessment from MPAP TWG members and participating controller and pilot technical observers.

The results of the simulation passed all of the test criteria. The MPAP TWG recommended the 3000-ft dual offset procedure for approval in the operational environment, given similar controller and pilot training, when the PRM system is used.

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Executive Summary

This simulation tested the procedure for simultaneous Instrument Landing System (ILS) approaches to two parallel runways spaced 3000 ft apart with one localizer offset by 2.5 degrees. Controllers monitored traffic using the Precision Runway Monitor (PRM) system, which included Final Monitor Aid (FMA) displays and a simulated radar sensor update rate of 1.0 second.

Aircraft blunders were used to test the ability of the system to maintain distances of at least 500 ft between aircraft during critical blunder situations. A blunder occurred when a Target Generation Facility (TGF) aircraft, established on an ILS approach, made an unexpected 30-degree turn toward an aircraft, usually a flight simulator, on an adjacent approach. Pilots of 80 percent of the blundering aircraft were instructed to disregard controller communications, simulating an inability to comply with controller instructions. Statistical analyses were conducted on the nonresponding aircraft blunders towards flight simulator targets. Test criterion violations (TCVs) occurred when the separation between aircraft was less than 500 ft. Blunders that would have resulted in aircraft miss distances of less than 500 ft had there been no controller intervention were classified as at-risk.

The following criteria were developed by the Multiple Parallel Approach Program (MPAP) Technical Work Group (TWG) to evaluate the study:

- the number of TCVs relative to the total number of at-risk, nonresponding blunders and to a predetermined target level of safety of no more than one fatal accident per 25,000,000 approaches;
    - ◊ Both the real-time simulation data and Monte Carlo techniques were used for this assessment.
- the frequency of No Transgression Zone (NTZ) entries and nuisance breakouts (NBOs);
    - ◊ NTZ entries occurred when aircraft entered the NTZ, not including aircraft that were directed to blunder. NBOs resulted when aircraft were broken out of the final approach for reasons other than a blunder, loss of longitudinal separation, or lost beacon signal.
- an evaluation of controller communications workload; and
- an operational assessment from MPAP TWG members, based on their expertise and judgment, and on evaluations from participating controller technical observers and pilot technical observers.

During the simulation, 284 blunders were initiated that would have resulted in aircraft miss distances of less than 500 ft had the controllers not intervened. Of the 284 blunders, 253 were nonresponding, making them worst-case blunders (WCBs). No TCVs occurred in any of the WCB situations. The confidence interval for the true TCV rate, based on the real-time results, was 0.0 to 2.1 percent. The TCV rates resulting from the two Monte Carlo simulations were 1.9 $\pm$ 0.1 percent and 0.11 $\pm$ 0.01 percent. These results were both consistent with the real-time simulation results and below the test criterion of 6.8 percent. In addition, the target level of safety of no more than one fatal accident per 25 million approaches was achieved.

An evaluation of NTZ entries and NBOs was conducted to assess system capacity and controller workload. In the approach course configuration, no NTZ entries occurred as a result of Total Navigation System Error (TNSE). TNSE was defined for this simulation as the difference between the actual flight path of the aircraft and its intended flight path. NBOs occurred in 1.3 percent of all nonblunder-related approaches due to TNSE-related events (i.e., aircraft approaching the NTZ). Both results were considered acceptable.

The TWG determined that the controller communications workload associated with TNSE-related events was at a satisfactory level based on their observations during the simulation and on questionnaires from participating controllers.

The MPAP TWG unanimously agreed that this 3000-ft configuration met all of the test criteria. Participating controller and pilot technical observers also supported this position. The development of pilot training and modifications to the controller training were significant in enabling a successful operation.

The pilot training consisted of viewing a video, RDU Precision Runway Monitor: A Pilot's Approach (FAA, 1995c), reading a Pilot Awareness Training Bulletin, and taking a self-administered test on pilot awareness. The pilots who flew the glass cockpit simulators, the MD90 and B747-400, were also required to read a Breakout Procedure Bulletin and complete a self-administered test on the subject. All pilots were required to hand-fly any ATC-directed breakout, which significantly improved the pilot/aircraft breakout performance.

Controllers were trained extensively for this simulation. They were each given a mandatory 8 hours of hands-on training. The training period was used for familiarization with the PRM equipment. Controllers were able to observe and attempt to resolve blunders while using new breakout phraseology that was developed as a result of information gained from previous simulations. In addition to the hands-on training, controllers were educated on procedures used in the cockpit after breakout instructions were received. This was accomplished through video recordings of simulator cockpits. The purpose of the video presentation was to allow controllers to make educated decisions.

In addition to the training developments and modifications, the TWG agreed that, in implementing the close parallel configuration, anti-blocking devices (ABDs) will be required in the ground radios. In the event that ABDs are not available, the air traffic facility will have two communication frequencies available for each close parallel runway, allowing the tower and monitor controllers to simultaneously broadcast on both frequencies to reduce the effect of blocked communications.

The test results demonstrated that the addition of controller and pilot training improved the procedure. Controller and pilot responsibilities were clearly understood, response times were sufficient, and adequate aircraft separation was maintained at all times. The TWG, therefore, recommended the procedure on simultaneous approaches to dual runways spaced 3000 ft apart with one localizer offset by 2.5 degrees for approval in the operational environment, given similar controller and pilot training, when the PRM system with a 1.0-second update rate is used.

1. Introduction

The ability of the National Airspace System (NAS) to meet future air traffic demands is a serious concern. Programs to improve NAS capacity have been underway since the early 1980s, both to reduce air traffic delays and to accommodate the increased demand. Contributing to capacity problems are the limitations imposed by current airport runway configurations and the associated air traffic separation criteria, particularly as related to aircraft executing instrument landing system (ILS) approaches under instrument meteorological conditions (IMC).

One way to improve system capacity and efficiency is to reduce the minimum runway spacings for parallel approach procedures. This approach permits current airports to be modified rather than requiring that new airports be built. Dual simultaneous ILS approaches are authorized, using current radar technology, to runways spaced 4300 ft and greater. In addition, dual simultaneous independent ILS approaches are authorized to runways spaced 3400 to 4300 ft apart when Precision Runway Monitor (PRM) systems with radar updates of 2.4 seconds or less are used (Federal Aviation Administration (FAA) 1995a). PRM systems provide controllers with high-precision secondary surveillance data and more frequent aircraft target update rates for monitoring aircraft on final approaches. PRM systems allow simultaneous ILS approaches to be conducted where they were previously restricted due to existing runway spacings and radar error.

1.1 The Multiple Parallel Approach Program Technical Work Group

The Multiple Parallel Approach Program (MPAP) Technical Work Group (TWG) has been investigating the use of triple, quadruple, and closely spaced dual parallel runway configurations through the conduct of real-time simulations at the William J. Hughes Technical Center in Atlantic City International Airport, NJ (Appendix A). The MPAP TWG is composed of FAA representatives from the Secondary Surveillance Product, Office of System Capacity and Requirements, Flight Standards Service, Air Traffic Rules and Procedures Service, Office of Air Traffic System Management, and Air Traffic Plans and Requirements Service.

The MPAP TWG brings together various areas of expertise to evaluate the feasibility of multiple parallel approaches in an effort to increase airport capacity in a safe and acceptable manner. The TWG evaluates simulated proposed operations against specific test criteria that have been developed over the course of many real-time simulations (see Section 2). Only after extensive review and evaluation of simulation results does the TWG conclude whether or not a proposed procedure should be recommended for approval in the operational environment.

1.2 Simulation-Related Definitions

The TWG has developed definitions and classifications that are specific to the MPAP real-time simulations. The following sections explain the simulation-related terms that are referred to throughout the report.

1.2.1 Blunders

During MPAP simulations, aircraft blunders are initiated to measure the ability of the system to maintain adequate separation between aircraft on final approaches during critical situations. A blunder occurs when an aircraft, already established on the final approach course, makes an unexpected turn towards another aircraft on an adjacent approach (see Figure 1). Adequate separation is maintained and the blunder is considered resolved if the minimum slant distance between the blundering aircraft and the evading aircraft at the closest proximity is 500 ft or greater.

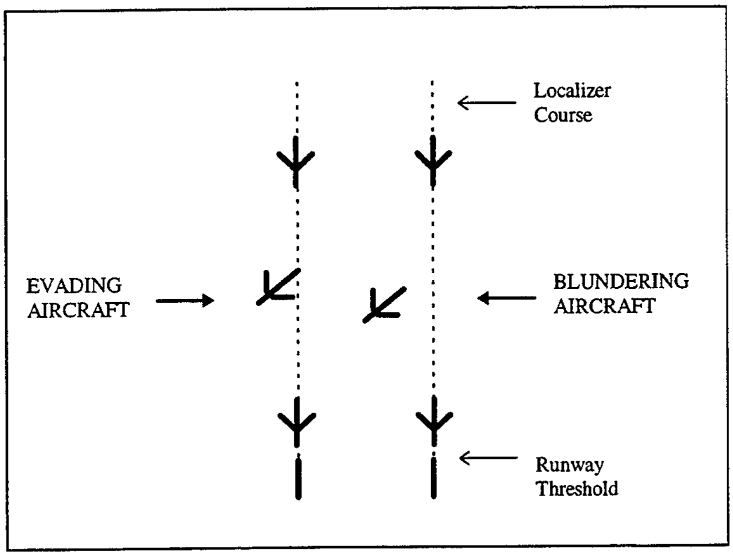


Figure 1. Aircraft blunder during parallel approach operations.

1.2.1.1 Test Criterion Violations

Any blunder that results in a miss distance of less than 500 ft between aircraft is considered a Test Criterion Violation (TCV). A valid TCV is one that could occur in the operational environment for any number of reasons and is not the result of a simulation anomaly (e.g., simulation hardware and software failure). If a blunder results in a TCV, the blunder is considered unresolved.

1.2.1.2 Blunder Classifications

One way to classify blunders is by the severity of the situation. For instance, blunders are classified as at risk or not at risk. An at-risk blunder is one that would have resulted in a miss distance of less than 500 ft had evasive maneuvers not been executed by either the blundering or the evading aircraft. An at-risk blunder is determined mathematically, based upon the projected courses of the blundering and evading aircraft at the start of the blunder. A blunder that is not at risk is one that would have resulted in a miss distance of 500 ft or greater without any evasive maneuvers being taken.

Blundering aircraft are also classified as responding or nonresponding. A responding aircraft is one in which the pilot of the blundering aircraft verbally responds with the controller's instructions and attempts to return the aircraft to the localizer course or execute some other evasive maneuver. A nonresponding aircraft is one in which the test director instructs the pilot to disregard controller communications, simulating an inability to correct the deviation from the approach course. This inability to correct a blunder is meant to simulate situations involving communications problems, hardware failures, or human error.

Blundering aircraft are scripted to turn at predetermined angles towards adjacent approach courses. In this simulation, all blundering aircraft executed 30-degree turns. A worst-case blunder (WCB) occurs when the blundering aircraft turns at an angle of 30 degrees and is nonresponding. In addition, blundering aircraft may either maintain altitude or descend.

1.2.2 No Transgression Zone Entries and Nuisance Breakouts

The final approach airspace is divided into two areas between the runways, the Normal Operating Zone (NOZ) and the No Transgression Zone (NTZ), as shown in Figure 2. The NOZ is the area between the NTZ and the final approach course where aircraft are permitted to fly. The NTZ is the 2000-ft wide area equidistant between final approach courses where aircraft are not permitted to enter.

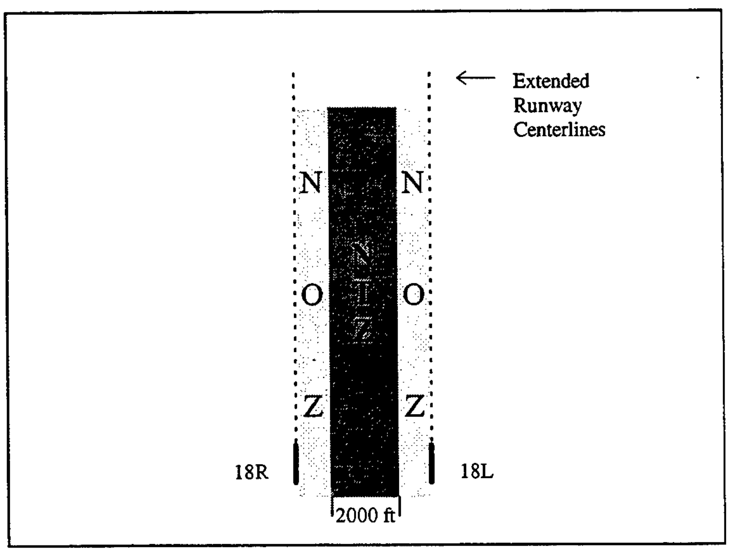


Figure 2. Normal Operating Zone and No Transgression Zone.

If an aircraft enters the NTZ, FAA regulations require the monitor controller to break any adjacent aircraft out of the approach. Because the NTZ is fixed at 2000 ft, the NOZ varies with runway separation. As separation between runways decreases, the NOZ decreases, providing less airspace for aircraft to fly along the ILS and a greater opportunity for aircraft to enter the NTZ.

As runways become more closely spaced, Total Navigation System Error (TNSE) becomes a concern. TNSE represents the difference between the actual flight path of an aircraft and its intended flight path. TNSE can be caused by flight technical error, avionics error, ILS signal error, and/or weather. TNSE may contribute to the occurrence of NTZ entries and nuisance breakouts (NBOs). An NTZ entry occurs when an aircraft enters the NTZ for reasons other than a blunder or breakout. An NBO occurs when an aircraft is broken out of its final approach course for reasons other than a blunder, loss of longitudinal separation, or lost beacon signal (i.e., aircraft target goes into coast).

2. Acceptance Criteria

The MPAP TWG uses four criteria to evaluate simulated operations: the TCV rate and risk analysis, the frequency of NTZ entries and NBOs, an evaluation of controller communications workload, and a TWG operational assessment.

2.1 Test Criterion Violation Rate and Risk Analysis

2.1.1 Test Criterion Violation Rate Derivation

The TCV rate is a measure of the system blunder resolution capability. Individual blunders are evaluated to determine whether or not they are at-risk. The number of TCVs divided by the number of at-risk blunders results in an initial estimate of the TCV rate. The number of at-risk, nonresponding blunders that occur during the real-time simulation, however, is relatively low, and therefore a large confidence interval results.

To ensure a more accurate measurement of the operational TCV rate, this criterion is measured using two fast-time computer, or Monte Carlo, simulations. The Monte Carlo simulations (i.e., the Blunder Risk Model (BRM) and the Airspace Simulation and Analysis for Terminal Instrument Procedures (TERPS) (ASAT) Model) each use data collected in the real-time simulation to model over 100 thousand at-risk blunders each, thus reducing the range of the confidence interval to a very small size. The methods used in the Monte Carlo simulations are described in Appendix B.

The TCV rate estimates from the Monte Carlo simulations are compared to the results of the real-time simulation to ensure that they are consistent. Specific procedures for the evaluation of TCV rate and risk analysis are contained in Section 11.2 and in Appendix C.

2.1.2 Maximum Acceptable Test Criterion Violation Rate

In the PRM Demonstration Report (1991), a TCV rate was computed from the population of all WCBs. It was found that a TCV rate not greater than 0.004 TCV per WCB would meet the target level of safety, provided that the overall 30-degree blunder rate did not exceed one 30-degree blunder per 2000 approaches. The real-time simulation, however, measures a TCV rate based on at-risk WCBs, not the population of all WCBs. Therefore, for comparison purposes, the population TCV rate is converted to an at-risk TCV rate. Based on a simulation of aircraft speeds and types, a conservative ratio of 1/17 at-risk WCB per WCB is applied, resulting in an at-risk TCV rate criterion of 6.8 percent for this simulation (see Appendix C).

2.1.3 Relationship Between Test Criterion Violation Rate and Risk Analysis

For this 3000-ft, 2.5-degree localizer offset simulation, a Monte Carlo at-risk TCV rate confidence interval not exceeding 6.8 percent would indicate a fatal accident rate below the target level of safety and would be acceptable. A Monte Carlo confidence interval that extends above 6.8 percent would indicate that the operation does not meet the target level of safety.

2.2 Frequency of No Transgression Zone Entries and Nuisance Breakouts

Measuring the frequency of NTZ entries and NBOs provides an assessment of how TNSE may have affected the simulated approach configuration. All NTZ entries and NBOs that occur as a result of TNSE are examined. The frequency of NTZ entries and NBOs has to be at an acceptable level as determined by the MPAP TWG.

2.3 Controller Communications Workload

The controller communications workload criterion has been developed as a result of past simulation observations of the effects of TNSE-related events. As runways become more closely spaced, the opportunity for NTZ entries and NBOs increases, as does radio frequency congestion due to those TNSE-related events. The TWG makes a subjective evaluation of the acceptability of the communications workload required of the controllers to maintain aircraft flight courses within the NOZ.

2.4 Technical Work Group Operational Assessment

An operational assessment of the approach configuration is conducted by MPAP TWG members. The assessment reflects the TWG's overall evaluation of the simulated procedure and recommendation regarding the feasibility of implementing the procedure in the operational environment. The operational assessment is based on all test results, on MPAP TWG expertise and judgment, and on evaluations from subject controllers, participating controller technical observers, and pilot technical observers.

3. Simulation Overview

3.1 Previous 3000-ft Simulation

In July 1994, a simulation was conducted to evaluate dual parallel runways spaced 3000 ft apart with one localizer offset by 2.5 degrees using the PRM system. Although some of the test acceptance criteria were met, the TWG did not recommend the simulated procedure, as tested. The following three specific problems areas were identified:

a. pilot training (i.e., pilot/aircraft response times following breakout instructions),

b. communications (i.e., blocked or clipped breakout instructions), and

c. controller training (i.e., controller breakout phraseology and procedures).

3.1.1 Pilot Training

Aircraft breakout maneuvering responses were inadequate to meet the target level of safety defined in the test criteria (i.e., 1 fatal accident in 25 million approaches). Pilots were not trained to perform the maneuver and were unfamiliar with Air Traffic Control (ATC)-directed breakouts between glide slope intercept and decision height. Unfamiliarity with breakouts was compounded by specific procedures required by highly automated flight control systems (i.e., flight director, flight management system, autopilot). The TWG, therefore, decided to determine if formal training would improve situational awareness and operational performance.

3.1.2 Communications

Blocked and clipped communications contributed to the severity of many blunders throughout the simulation. The time available for breakout communications was limited and did not allow for identification of blocked communications and subsequent rebroadcasts. When communications were blocked or clipped, aircraft responding to the repeated transmissions were frequently not able to execute evasive maneuvers in a timely manner. The TWG proposed investigating methods to identify and resolve blocked and clipped communications.

3.1.3 Controller Training

Prior to the simulation, controllers were briefed on the standard phraseology to be used in the event of a blunder. During the simulation, however, breakout phraseologies varied in content and duration. This resulted in two effects. First, pilots did not always receive both the heading and altitude assignment in the initial breakout transmissions, causing some delays. Second, nonstandard phraseology usage sometimes resulted in a lack of urgency or confusion to the flight crews. Controller transmissions may have been less ambiguous had more emphasis been placed on the use of standardized phraseology. The TWG proposed investigating methods to improve controller training.

3.2 Multiple Parallel Approach Program Investigative Groups

Over the course of a year, action was taken to resolve the problem areas identified in the July 1994 simulation. TWG members, controller technical observers, and pilot technical observers participated in MPAP-formed subgroups or investigative groups, whose goals were to explore ways to improve performance in each of the problem areas through additional studies. The TWG believed that such improvements could effect a successful 3000-ft, 2.5-degree offset operation.

3.2.1 Pilot Training Investigative Group

The MPAP TWG conducted two studies to determine the effect of training on pilot breakout performance. Since the time to initiate the breakout maneuver was longer in glass cockpit aircraft than in older analog-type aircraft, the studies were conducted in two glass cockpit simulators, a B747-400 and an A320. Two areas of training were identified: pilot awareness training and aircraft-specific breakout procedure training.

The studies were divided into several phases, with each phase containing more training than the preceding phase. The first phase used pilots without training to establish a baseline for breakout performance. The next phase determined the effect of pilot awareness training on breakout performance. Pilot awareness training consisted of viewing a video (FAA, 1995c) about the PRM system, reading a Pilot Awareness Bulletin, and taking a short self-administered test. Although the pilot awareness training improved the breakout performance, it was felt that more improvement was needed. The next phase added aircraft-specific breakout procedure training. This training consisted of the pilot reading a Procedure Bulletin and completing a short self-administered test.

It was observed during these simulations that the hand-flown breakouts were performed more quickly than the autopilot-flown breakouts. This observation led to the next phase of testing, a comparison of hand-flown breakout performance and autopilot-flown breakout performance. The B747-400 was selected for this study because its autopilot breakout performance was slower than that of the A320. There was a significant improvement in breakout performance when the B747-400 was hand-flown during a breakout as compared to when the autopilot was used to perform the maneuver.

The conclusions reached during this series of mini-simulations significantly influenced the pilot training program used in the October 1995 3000-ft simulation.

3.2.2 Communications Investigative Group

The occurrence of blocked communications was identified as a major factor contributing to the severity of blunder outcomes in the July 1994 simulation. The controllers were often unaware of the blocked communications, resulting in longer system response times. To combat this problem, the communications investigative group began research on VHF/UHF anti-blocking devices (ABDs). These ABDs would provide the controller and/or aircrew with an indication that outgoing messages were blocked by someone else's transmission. An ABD has been developed and implemented in England. Several of the devices were acquired and are currently being tested for compatibility with FAA approved systems. Since the ABD testing was not complete at the time, ABDs were not incorporated into the October 1995 simulation. However, the communications issue was addressed indirectly in the October simulation through the improved controller training package, which included new breakout phraseology.

3.2.3 Controller Training Investigative Group

The controller training investigative group made several modifications to the controller training syllabus in an effort to increase controller awareness and preparedness for monitoring closely spaced approach configurations. One significant change involved the controller breakout instruction phraseology.

In the July 1994 3000-ft simulation, the controller breakout phraseology from FAA Order 7110.65H (FAA, 1995a) was used, which consisted of the aircraft call sign followed by the breakout instructions. Due to excessive clipped aircraft call signs at the beginning of the messages, pilots did not always know who the calls were for and, thus, did not always respond.

Therefore, changes were made to the phraseology and tested in an August 1995 triple approach simulation. The modified phraseology began with the aircraft call sign, followed by the addition of the phrase, "Traffic Alert", which was used in an effort to increase awareness of the urgency of the situation, followed by a repeat of the aircraft call sign, followed by the instructions. After the simulation, it was determined that the phraseology resolved the clipped communications problems (with the repeat of the aircraft call sign), but the phraseology message itself was too lengthy and delivery was poor in many situations.

As a result, the phraseology was modified once more for the October 1995 3000-ft, 2.5-degree localizer offset simulation. This time it was shortened by omitting the first aircraft call sign to allow for an easier, quicker delivery of instructions. Putting the phrase, "Traffic Alert", at the beginning of the message had a twofold benefit: heighten the awareness of all listeners on the frequency as to the urgency of the impending situation and help prevent the clip of the aircraft call sign prior to the breakout instruction.

In addition to the new breakout phraseology, the modified controller training syllabus also emphasized the need for a timely response from the controller and highlighted the effect of the controller breakout instruction on the aircrew's workload. A video was developed using video recordings from previous simulations, which demonstrated reactions and responses of flight crews to breakout instructions, including instructions to descend. The training syllabus stressed the importance of completing the prescribed phraseology in one transmission. This was based on past observations that information in a later transmission was sometimes missed due to breakout activity in the cockpit or to blocked or clipped communications as the result of frequency usage.

The amount of controller hands-on training was changed to require controllers to complete a mandatory 8 hours on position prior to participating in actual test runs. This allowed for sufficient practice of blunder detection and the use of the prescribed breakout phraseology.

3.3 October 1995 3000-ft Simulation

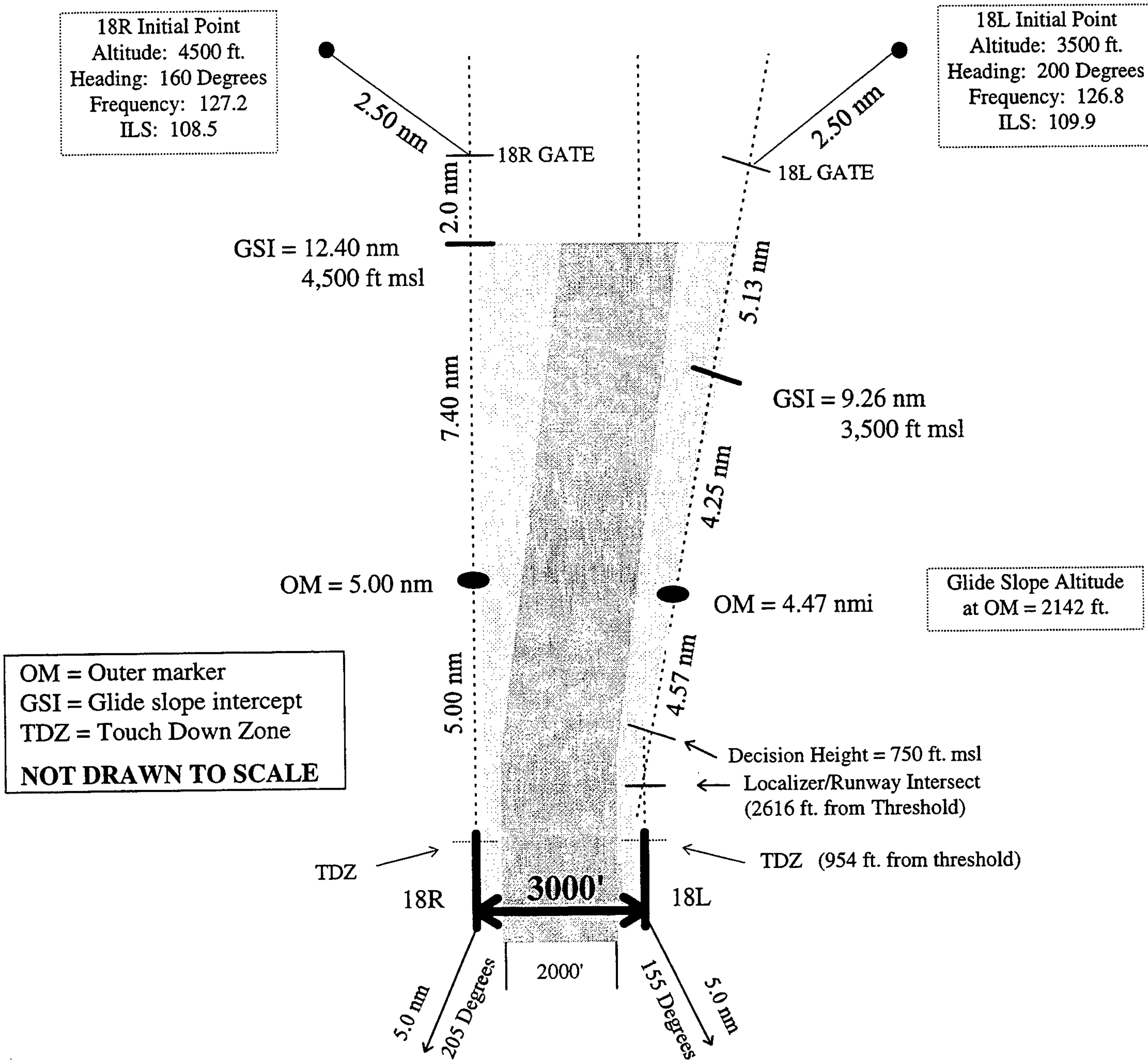
In October 1995, a simulation was conducted to re-evaluate the procedures for simultaneous independent ILS approaches to two parallel runways spaced 3000 ft apart with one localizer offset by 2.5 degrees. This study is the focus of the remainder of this report.

3.3.1 Airport Configuration

Controllers monitored traffic using a simulated PRM system with a 1.0-second update rate. The airport layout, runways, and arrival frequencies emulated an airport with even thresholds, glide slopes of 3 degrees, and field elevation of 500 ft MSL (see Figure 3). The turn-on altitude for runway 18R was 4500 ft MSL with a glide slope intercept of 12.40 nm. The turn-on altitude for runway 18L was 3500 ft MSL with a glide slope intercept of 9.26 nm.

3.3.2 Test Runs

The simulation was conducted over a 2-week period, Saturdays and Sundays excluded. Three 2-hour runs were conducted each day. A total of 10 runs (5 runs for each controller group) were



AIRPORT DATA

Field Elevation:	500 ft msl
Magnetic Variation:	0
Runways:	10,000 ft x 150 ft
Altimeter:	29.92
Weather:	300 ft ceiling and 3/4 mile visibility

Figure 3. Airport configuration for a 2.5-degree localizer offset.

dedicated to the controller briefing and training. Also, only two runs were conducted on the last day of the two weeks of testing. Therefore, data from a total of 19 runs were collected and analyzed.

4. Experimental Apparatus

The development of the real-time simulation environment at the William J. Hughes Technical Center in Atlantic City, NJ has made real-time simulation testing one of the most advanced methods for evaluating ATC procedures development. The Technical Center laboratories contain fully-operational ATC displays that have the capability to interface with remote flight simulators across the country. With this end-to-end simulation capability, tests can be conducted to collect data on controller and pilot performance issues that cannot be measured in the operational environment.

4.1 Target Generation Facility Laboratory

The TGF is an advanced simulation system designed to support testing of current and future ATC systems at the William J. Hughes Technical Center. For this simulation, the functionality of the TGF system was partitioned into three subsystems: simulation pilot, target generation, and development and support.

The simulation pilot workstations (SPWs) were computer workstations containing a communication system that provided an audio interface with the monitor controllers. Simulation pilot operators (SPOs) used the SPWs to fly the simulated aircraft and commanded them in accordance with ATC instructions.

The target generation (TG) subsystem consisted of a TG chassis and an external interface (EI) chassis. The TG performed all modeling within the TGF and correlated dynamic data, such as aircraft state vectors and radar performance, with known flight plans. The EI was responsible for creating the exact form and content of the digitized radar messages sent to the ATC system under test. Controller-pilot voice communications were processed through an AMECOM voice communications system.

The development and support subsystem provided the basic post-exercise data reduction and analysis capabilities. In addition, this subsystem provided the capabilities necessary to maintain and/or enhance the TGF software.

In total, the TGF modeled a logical view of the ATC environment, including long and short range radar sensors, controlled airspace, weather conditions, air traffic, and aircraft performance. The TGF configuration for the 3000-ft, 2.5-degree offset simulation is shown in Figure 4.

4.2 Radar System and Controller Displays

The final monitor controllers used prototypes of the components of the PRM system located in the Systems Display Laboratory at the William J. Hughes Technical Center. The components consisted of Final Monitor Aid displays and a simulated electronic scanning beacon sensor with a 1.0-second update rate.

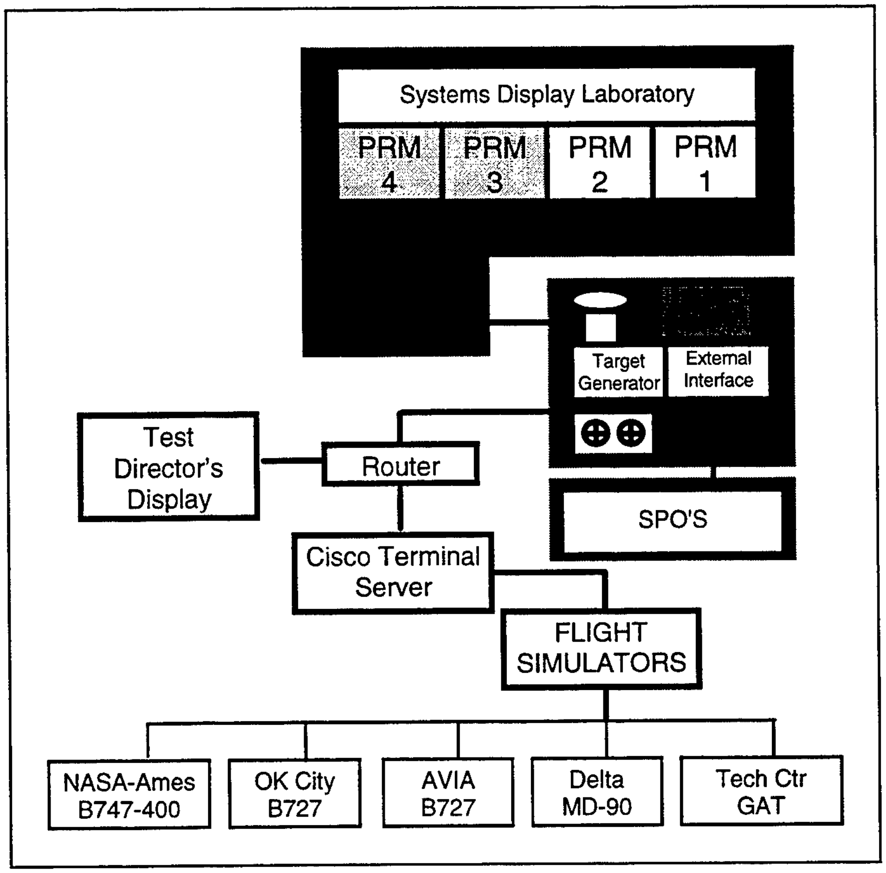


Figure 4. Target generation facility configuration.

4.2.1 Final Monitor Aid Displays

FMAs are high resolution color displays equipped with the controller alert system hardware and software used in the simulated PRM system. The FMA displays used in this simulation included alert algorithms that provided the target predictors, color change alerts when targets penetrated or were predicted to penetrate the NTZ, color change alerts if the aircraft transponders became inoperative, synthesized voice alerts, digital mapping, and other features contained in the PRM system.

Graphics for the FMAs used during the simulation were generated by a Metheus graphics driver, and the operating system was driven by a micro-VAX computer. In addition to the mapping information currently provided by ARTS displays, the FMAs provided features to aid controllers in the early detection of blunders and the control of airspace. These included independent magnification capabilities, color coding, aircraft predictor lines, and audio and visual warnings.

FMAs provide the capability to adjust the horizontal and/or vertical ratio of the display. Horizontal and vertical (X-Y) axes can be scaled independently to improve the controller's ability to detect aircraft movement away from the extended runway centerline. However, for this

simulation, the magnification of the controllers' displays was set at 8 times for the horizontal axis and 2 times for the vertical axis, for a 4:1 aspect ratio. Controllers were not permitted to adjust the ratio during the simulation.

For each of the runways, ILS approach centerlines were displayed as dashed white lines, where each dash and each space between dashes represented 1 nm. Solid light blue lines were displayed on each side of the ILS centerline to delineate 200-ft deviations from the localizer. The 2000-ft wide NTZ, located equidistant between localizer courses, was outlined in red.

A predictor line was used in the generation of the audio and visual alerts. The predictor line, which was affixed to each aircraft target, indicated where the aircraft would have been in 10 seconds had it continued on the same path. The predictor line provided controllers advance notice of the path of the aircraft. The predictor line can be varied but, for this simulation, it was set to 10 seconds.

Aircraft targets and alphanumeric data blocks were presented in green as long as aircraft maintained, and were predicted to maintain, approaches within the NOZ. When a predictor line indicated that an aircraft was within 10 seconds of entering the NTZ, the green aircraft target and data block changed to yellow. An auditory warning also sounded at that time (e.g., American 211) to notify controllers of the impending NTZ entry. If an aircraft entered the NTZ, the yellow aircraft target and data block immediately changed to red.

4.2.2 Electronic Scanning Radar Sensor

The simulated Electronic Scanning (E-Scan) sensor used a monopulse azimuth measurement technique, which provided accuracy of better than 1 milliradian (0.06 degrees) root mean square (rms). The range error associated with the system was ±30 ft with an rms error of 25 ft. The specified system delay from the antenna to the display was up to 0.5 seconds. The alpha-beta tracker, used to smooth aircraft position data, had gains of 0.3 (alpha) and 0.245 (beta) in the calculation of aircraft positions and velocities, respectively.

4.2.3 Navigational Error Model

Aircraft position with respect to the final approach course, the NTZ, and other aircraft, had to be realistically presented on the radar display to accurately assess the controllers' ability to detect blunders. In developing the navigational error model for TGF aircraft, two criteria were used. First, aggregate errors had to accurately reflect the TNSE distribution of aircraft as they flew ILS approaches. Second, displayed flight paths of aircraft had to look reasonable to the controllers (i.e., deviations from the localizer centerline had to appear typical of aircraft flying an ILS approach during IMC). The navigational error model used for this simulation was based upon data collected at Chicago O'Hare Airport (Timoteo & Thomas, 1989), Memphis Airport (PRM Program Office, 1991), and Los Angeles International Airport (LAX) (DiMeo, Melville, Churchwell, & Hubert, 1993).

4.3 Flight Simulators

Four full-motion air carrier simulators and one general aviation trainer (GAT) were integrated into the simulation. They assumed the configuration of aircraft flying the localizer course and replaced certain TGF aircraft that entered the simulation. Table 1 lists the participating simulator aircraft.

Table 1. Participating Flight Simulator Types, Sponsoring Facilities, and Locations

SIMULATOR TYPE	SPONSORING FACILITY and LOCATION
1. B747-400	NASA-Ames, Moffett Field, CA
2. MD90	Delta Airlines Inc., Atlanta, GA
3. B727	AVIA Inc., Costa Mesa, CA
4. B727	Mike Monroney Aeronautical Center; Oklahoma City, OK
5. GAT	William J. Hughes Technical Center, Atlantic City International Airport, NJ

Flight simulators were an integral part of the real-time simulation because they provided a representative sample of NAS users. The simulators also generated more accurate pilot and aircraft performance data than the computer-generated aircraft.

The type of approach flown by pilots of the flight simulators (i.e., coupled autopilot, hand-flown using the flight director, raw data) was determined based upon surveys of current airline procedures. For simulators that were glass cockpit/FMS-equipped (NASA B747-400, Delta MD90), 80 percent of the approaches were scripted to be flown using a coupled autopilot and 20 percent were to be hand-flown using the flight director. For analog/conventional simulators (AVIA B727, Oklahoma City B727), 50 percent of the approaches were scripted to be flown using a coupled autopilot and 50 percent were to be hand-flown. The GAT was scripted such that 5 percent of its approaches were to be flown using a coupled autopilot, 45 percent were to be hand-flown, and 50 percent were to be flown using raw data.

Crosswinds were introduced to flight simulator approaches to provide pilots with a realistic flight environment. Three direct crosswind conditions were assigned: no wind, a 15-kt wind from the east, or a 15-kt wind from the west. All flight simulators were assigned the same wind condition for any given run.

5. Simulation Instruments

5.1 Traffic Samples

Four traffic samples were generated for the simulation based on a survey of instrument operations for several level 5 (i.e., airports that have 100 or more instrument operations per hour)

terminal radar approach control (TRACON) facilities. Traffic samples were lists of all the aircraft arrivals, which included call signs, beacon codes, aircraft types, and start times for entering the traffic scenarios. Approximately 65 aircraft per runway entered the simulation scenario per 2-hour run. Departing aircraft were also programmed into the traffic scenarios to generate a more realistic ATC environment. Approximately 61 aircraft per runway were departures per 2-hour run.

A representative number of air carriers (65 percent), commuters (30 percent), and general aviation aircraft (5 percent) targets constituted the traffic mix. Air carriers (jets) and commuters (turboprops) were assigned initial indicated airspeeds of 180-200 kts. General aviation aircraft (props) were assigned initial indicated airspeeds of 130-150 kts. Speed overtakes were not intentionally scripted into the traffic samples; however, overtakes did randomly occur throughout the simulation, and monitor controllers had to make speed adjustments when necessary.

5.2 Blunder Scripts

The traffic samples were developed not only to generate traffic for the simulation but also to determine when aircraft would be aligned for potential conflicts. The traffic samples were devised prior to the simulation and observed on the radar scopes to determine the call signs of adjacent aircraft targets and the times of potential conflicts. This information was recorded to generate blunder scripts. The blunder scripts noted aircraft pairs, along with the response conditions and blunder paths (see Section 7.1), for the test director to use during simulation runs.

5.3 Closest Point of Approach Prediction Tool

The Closest Point of Approach (CPA) prediction tool is a software tool used by the test director during MPAP simulations to create potential at-risk blunders. The CPA is defined as the smallest slant range distance between two aircraft involved in a conflict. The tool uses aircraft velocities, headings, and degree of turn for each aircraft pair in the real-time calculation of a predicted CPA. The tool also calculates the elapsed time until the predicted CPA is reached, given an immediate execution of a blunder. All of the CPA prediction tool information is updated every second.

During this simulation, the CPA prediction tool presented call signs of predetermined potential blunder aircraft pairs in a window on the test director's display. The window could accommodate information on eight aircraft pairs at a time. The aircraft pairs, which appeared in the window, were determined by the blunder scripts; however, the test director had the capability to delete scripted aircraft pairs and/or add pairs that were not originally included on the blunder scripts.

6. Subjects

6.1 Final Monitor Controllers

A total of 12 air traffic controllers with experience in simultaneous parallel approach operations participated as test subjects. Controllers were selected from the following TRACON facilities: Atlanta, Pittsburgh, St. Louis, and Detroit. All controllers were volunteers selected in agreement with their NATCA offices.

Controllers were scheduled to participate in two groups, one group of six participating each week. The first group participated October 16-20, 1995, and the second group participated October 23-27, 1995. Individual controllers were scheduled to work as monitor controllers for half of each 2-hour run. A controller rotation period occurred at the midpoint of each 2-hour run to simulate actual work rotations and to give monitor controllers a rest. Each controller participated in only 1 hour of each 2-hour run. Furthermore, controllers were not scheduled to participate in more than three runs on any day of the simulation.

6.1.1 Controller Briefing

Controllers were given a briefing prior to participating in the simulation. The briefing included a description of the MPAP TWG's composition and program goals. The simulation purpose was also explained, followed by a presentation of a PRM video shown to familiarize controllers with the components of the PRM system. The briefing package included diagrams of the simulated airport approach area configuration and the approach plates that were contained in the pilot briefings. Controller schedules of participation were also included. Appendix D contains the complete briefing as distributed to the test controllers.

The primary focus of the briefing package was on controller responsibility. Controllers were given an overview of the responsibilities of the final monitor controller, which included maintaining longitudinal separation and lateral separation between aircraft on adjacent localizers and ensuring each aircraft established contact with the tower prior to the first simultaneous approach fix. Controllers were told not to make speed adjustments to aircraft inside the final approach fixes and were reminded of the monitor controller's override capabilities on the local control frequencies.

The briefer read a paragraph from the Airman's Information Manual (FAR, 1995) to the controllers that stated that the primary navigation responsibility was to rest with the pilot, and controller-issued instructions were therefore limited to those necessary to ensure separation between aircraft and to contain the aircraft flight paths within the NOZ. Aircraft that were observed to enter the NTZ were to be instructed to alter course left or right, as appropriate, to return to the desired courses. Unless altitude separation was assured, controllers monitoring the adjacent localizer courses were to take immediate action to require aircraft in potential conflict to alter flight paths to avoid deviating aircraft.

Controllers were instructed to use the following phraseology in the event that an aircraft overshot the turn-on or continued on a flight path that would penetrate the NTZ:

- "You have crossed the final approach course. Turn (left/right) immediately and return to the localizer/azimuth course," or

- "Turn (left/right) and return to the localizer/azimuth course."

Controllers were instructed to use the following phraseology if an aircraft on an adjacent approach was in potential conflict with a deviating aircraft: TRAFFIC ALERT, aircraft call sign, turn (left/right) immediately heading (degrees), climb and maintain (altitude). (Proposed change to FAA Order 7110.65)

In addition, controllers were instructed to use the following standard breakout headings and altitudes, whenever feasible, for aircraft on adjacent courses to deviating aircraft:

- Runway 18R: Turn right immediately heading two seven zero, climb and maintain five thousand.

- Runway 18L: Turn left immediately heading zero niner zero, climb and maintain four thousand.

6.1.2 Controller Training

Controllers were given hands-on training with the PRM equipment following the briefing and prior to actual test runs. Each group of controllers rotated through monitor positions over the course of five 2-hour practice runs. The purpose of the training was to familiarize the controllers with the FMA displays and to expose them to blunder situations. Controllers were encouraged to practice the standard phraseology and to coordinate actions with other monitor controllers during blunders.

6.2 Pilots

A total of 51 pilots participated in flight simulators during the simulation. Of these, 41 were air carrier pilots with an average of 11,658 total flight hours, and 10 were general aviation, military, or commuter pilots with an average of 2,850 total flight hours. Air carrier pilots recruited to participate in the simulation were required to be qualified in type and current on the aircraft represented by the simulator to which they were assigned. Pilots recruited to fly the GAT were required to hold commercial flight certificates with multi-engine and instrument ratings.

Three pilots were assigned to each air carrier flight simulator site each day, except at the NASA facility where two pilots flew together the entire day. Single pilot IFR operations were conducted at the GAT, therefore, two pilots divided the flying time each day. Each pilot flew approximately 8 approaches in the air carrier simulators and approximately 10 approaches in the GAT each day.

6.2.1 Pilot Briefing and Training

Pilots reported 1 hour before the start of the simulation for training. After reviewing a Pilot Briefing Handout (Appendix E), pilots were shown a 12-minute video describing the PRM system (FAA, 1995c). Following the video, pilots were given approach plates and an airport information page. They were required to read a Pilot Awareness Training Bulletin (Appendix E) and take a self-administered test to reinforce what they had read. Pilots assigned to the glass cockpit simulators (i.e., B747-400 and MD90) were required to read a Breakout Procedure Bulletin and take a self-administered test on the material. This bulletin presented a hand-flown

breakout procedure that emphasized turning off the flight director of the pilot flying until the pilot not flying changed the flight director inputs to conform with the breakout instructions.

This training session was designed to be similar to what a pilot could encounter at an airline. After reporting for work, the pilot would find the training bulletins in his or her mailbox along with self-administered tests. The pilot would read the bulletins, complete the tests, and hand them in to the chief pilot. The pilot's training records would be updated accordingly. The Pilot Briefing Handout, the Pilot Awareness Training Bulletin, the Breakout Procedure Bulletins, and the corresponding self-administered tests are located in Appendix E.

6.2.2 Pilot Briefing Materials

6.2.2.1 Approach Information Index Cards

Prior to each approach, the pilots were handed an Approach Information Index Card to place on the cockpit console. These cards provided simulator pilots, site coordinators (see Section 8.6), and technicians with the necessary details to insure that the simulators were in the proper configuration at the initial point before entering the simulation. The following information was included on the index card:

a. runway,

b. type aircraft and equipment displayed on FMA display,

c. initial point time at which the aircraft was scheduled to enter the simulation,

d. aircraft call sign (located in center of card in large font for ease of recognition),

e. initial heading to fly,

f. initial altitude,

g. initial indicated airspeed,

h. localizer frequency,

i. tower frequency,

j. transponder code,

k. type of approach in accordance with percentage based on survey of airlines,

l. traffic sample number,

m. site corresponding to each set of index cards and traffic sample number, and

n. index number.

6.2.2.2 Approach Plates and Airport Information Page

Pilots were supplied with approach plates designed specifically for simultaneous close parallel approaches, along with an airport information page. The approach plates differed from those used for normal ILS approaches in that they included information designed to heighten pilot awareness of close parallel ILS operations. Three notes were placed in the plan view section of

the approach plates. The first note identified the altitude below which no descending breakouts would be issued. The second note authorized simultaneous close parallel approaches with the adjacent runway. The third note required the pilot to read the airport information page before flying the close parallel approach. In the heading section of the approach plates, under the procedure identification, the words Close Parallel were added.

The airport information page contained an illustration of the centerline spacing between runways, the pilot requirements for flying the simultaneous close parallel approach, a paragraph on breakout descents, a section on controller phraseology, and emphasis on the importance of an immediate pilot response to a controller's breakout instructions. The approach plates and airport information page are located in Appendix F.

6.2.2.3 Automatic Terminal Information System Cards

In order to maintain a realistic environment during the simulation, pilots were provided with written automatic terminal information system (ATIS) cards. These cards acted as the ATIS broadcast the pilots would listen to before entering the airport environment. The ceiling, visibility, restrictions to visibility, temperature, dewpoint, wind, altimeter setting, approaches in use, and letter identifier were written on the cards. Three separate cards were used to reflect the changing wind conditions used in the simulation. These cards were identified as information alpha, information bravo, and information charlie, respectively. An example of the ATIS cards is contained in Appendix E.

7. Experimental Design

7.1 Experimental Factors Description

All blundering aircraft in the simulation were scripted to have certain response conditions (responding or nonresponding) and blunder paths (maintain altitude or descend). In addition, blunders were distributed along the localizer courses and initiated towards certain types of aircraft according to predetermined percentages.

7.1.1 Response Condition

To simulate worst-case situations, where blundering aircraft were unable to correct their deviations, pilots of blundering aircraft were often instructed to disregard controller communications, thereby not correcting the blunder. A blunder with this condition was referred to as a nonresponding blunder. Throughout the simulation, 80 percent of the blundering aircraft were scripted to be nonresponding.

7.1.2 Blunder Path

For additional realism, the paths of blundering aircraft were scripted to either maintain altitude or descend on a 3-degree glidepath. Fifty percent were scripted for each condition.

7.1.3 Blunder Distribution Along Localizer Course

For purposes of tracking where blunders occurred along the localizer courses, distances from the runway thresholds were binned into the following groups: 1-3 nm, 3-5 nm, 5-7 nm, 7-9 nm, and 9-12 nm. The goal was to have 18 percent of the blunders occur in each bin, except for the 9-12 nm bin, which had a blunder initiation goal of 28 percent.

7.1.4 Aircraft Types and Flight Systems

Blunders were also initiated according to predetermined traffic mix percentages based upon aircraft types and flight systems. Table 2 summarizes the blunder initiation traffic mix percentage goals. See Appendix G for a summary of all of the simulation distribution goals and actual results.

Table 2. Blunder Initiation Goals for Aircraft Types and Flight Systems

	Flight Simulator	Goal (percent)
Evading Aircraft Type		
Heavy Jet	B747-400	30
Jet	B727s, MD90	65
General Aviation	GAT	5
Evading Aircraft Flight System		
Glass	B747-400, MD90	60
Analog/Conventional	B727s	35
General Aviation	GAT	5

7.2 Performance Measures

Dependent variables in the simulation included CPA, frequency of NTZ entries, and frequency of NBOs.

7.2.1 Closest Point of Approach

Blunder resolution performance was measured by determining the proportion of successfully resolved conflicts relative to the total number of blunders that would have resulted in TCVs had there been no controller intervention. The resolution of conflicts was examined by calculating CPAs. The CPA was the smallest slant range distance between two aircraft involved in a conflict (measured in ft). The distance was measured from the center of each aircraft involved in the conflict and was updated every second.

7.2.2 Frequency of No Transgression Zone Entries and Nuisance Breakouts

The number of NTZ entries and NBOs was determined and used as a measure of system capacity. Frequencies of NTZ entries and NBOs were computed through review of PRM video and audio recordings of each run of the simulation.

7.3 Procedure

Controllers staffed two final approach monitor positions. They monitored the flight paths of the aircraft on their assigned runways and their task was to ensure that aircraft maintained the required separation. Aircraft blunders were initiated to test the ability of the ATC system to maintain adequate distances between aircraft during critical situations. During each run of the simulation, blunders occurred without warning to the controllers. During blunder events, controllers issued control instructions to attempt to resolve the situation.

Blunder scripts, traffic samples, and the CPA prediction tool guided the initiation of the blunders. Approximately 16 blunders were scripted per 2-hour run. Blunders did not occur within less than 3 minutes of each other or within 1 nm of the runway thresholds. All blundering aircraft were TGF aircraft and most evading aircraft were flight simulators.

8. Support Personnel

8.1 Test Director

Simulation runs and aircraft blunders were initiated at the instruction of the simulation test director. Individuals who assumed the role of test director had extensive ATC experience and were trained to work with the CPA prediction tool. The test director was responsible for initiating blunders based upon the information provided by the blunder scripts, the CPA prediction tool, and his expert judgment.

8.2 Controller Technical Observers

Four controller technical observers participated in the simulation, all of whom had ATC experience and were familiar with the MPAP project. Controller technical observers monitored controller actions during each simulation run. Their duties included documenting discrepancies between issued control instructions and actual aircraft responses, alerting responsible parties to any problems that may have occurred during the test (e.g., computer failure, stuck microphone), assisting controllers with the preparation of blunder statements, and preparing a controller technical observer assessment at the end of the simulation (see Section 11.6.1). The assessment included their opinions and conclusions concerning the conduct of the simulation as well as any recommendations to the MPAP TWG.

8.3 Pilot Technical Observers

A group of former air carrier pilots with experience in numerous air carrier aircraft, including several thousand hours in Boeing glass cockpits, participated as pilot technical observers in the simulation. They had acted as site coordinators in previous simulations and were involved in the development of the pilot training used in this simulation. They observed the 3000-ft simulation from several viewpoints, including the simulator cockpits, the test director's station, and the visitor's observation room. In addition, they reviewed videotapes of breakouts from all of the simulator sites.

8.4 Simulation Pilot Operators

SPOs operated the TGF aircraft during simulation runs. SPOs controlled blundering aircraft at the instruction of the test director and responded to controller instructions (except during nonresponding blunders) by entering aircraft heading and/or altitude changes using their specialized computer keyboards and displays.

8.5 Tower Controllers

To add realism to the communications on the final monitor frequencies, three non-subject tower controllers rotated through performing local tower control functions. They cleared aircraft for departure and landing and advised frequency changes.

8.6 Site Coordinators

Site coordinators were assigned to each flight simulator location to coordinate efforts with the test director at the William J. Hughes Technical Center and to support pilots during their participation in the simulation. They were provided with a Site Coordinator Briefing Materials package that detailed their duties and responsibilities. Site coordinators were current or retired airline pilots who had experience with MPAP real-time simulations and with the type of aircraft represented by the flight simulator to which they were assigned.

Site coordinators acted as observers and were trained to refrain from providing any help to the aircrews that would invalidate the simulation data. Their responsibilities included briefing aircrews, providing pilots with flight information prior to each approach, documenting approach information, and administering questionnaires to the pilots. The Site Coordinator Briefing Materials are located in Appendix H.

8.7 Simulation Observer

A simulation observer manually documented information from the test director's station, including blunder occurrences, NBOs, NTZ entries, potential TCVs, lost beacon signals (i.e., aircraft that went into coast (CST), indicating a loss of radar tracking), and system problems (e.g., communications failure, hardware/software failure).

9. Data Collection

9.1 Computer-Generated Data Files

The generation of data files by the TGF allowed a detailed examination of the performance of the ATC system in resolving blunders. Data files included information on parallel conflict frequencies, parallel conflict slant range miss distances, and aircraft position/track data.

Data files were also generated at the flight simulator sites. These files contained detailed information about aircraft performance (e.g., angle of bank, rate of climb, pitch angle), allowing detailed analysis of pilot/aircraft response.

9.2 Audio and Video Recordings

The communication frequencies of both blundering and evading aircraft and visual components of the PRM display throughout each run were recorded on a Super-VHS video cassette recorder. Backup audio recordings were generated using a 20-channel DICTAPHONE audio recorder and a 9-channel IONICA audio recorder. Both the DICTAPHONE and the IONICA systems were recorded from the AMECOM system and operated independently of one another and of the TGF operating system.

Video cameras were set up in all flight simulators to capture the interactions between the pilots in the cockpit and between pilots and controllers. In addition, a video camera was mounted behind the controllers in the monitor room to capture all interactions and coordinating efforts between controllers during blunders and other events in the simulation.

The videotapes were used in the examination of TCVs, the evaluation of controller phraseology and other message characteristics, the extraction of controller and pilot response times, the identification of NTZ entries and NBOs, and the verification of computer-generated data file information.

9.3 Questionnaires

9.3.1 Controller Questionnaires

At the end of each day, controllers completed End-of-Day Controller Questionnaires that addressed the level of activity, stress, and mental effort they experienced throughout the day. In addition, when the controller technical observers believed a TCV had occurred, they instructed controllers to describe the conflict in detail on a Blunder Statement. Controllers also completed a Post-Simulation Questionnaire at the conclusion of their participation in the simulation. The Post-Simulation Questionnaire addressed issues such as the operational viability of the runway configuration, the degree of communications workload, and simulation realism. The controller questionnaires are found in Appendix I.

9.3.2 Pilot Questionnaires

Two pilot questionnaires were employed in this simulation. After every breakout, site coordinators used a Pilot Breakout Questionnaire to evaluate the pilot's performance from initial controller transmission to the resultant breakout maneuver. Second, flight simulator pilots completed a Flight Crew Opinion Survey at the conclusion of their participation in the simulation. The Flight Crew Opinion Survey collected subjective data on such issues as the adequacy of the training materials, approach plates, information page, and breakout instructions. Both flight simulator pilot questionnaires can be found in Appendix J.

9.4 Observer Logs

Controller technical observers and site coordinators each recorded information on logs designed specifically for their tasks. In general, the controller technical observer logs were designed to capture information pertaining to blunders, potential TCVs, NBOs, NTZ entries, and simulation

problems to be used in conjunction with the computer-generated data. Site coordinator logs were developed to record approach and breakout information, such as approach identification, simulator problems, approach abnormalities, answers to the Pilot Breakout Questionnaires, and comments from the observer or the pilot concerning the approach. Examples of the observer logs are located in Appendix K.

10. Assessment Methodology

All data collection sources, including computer-generated data, video and audio data, pilot and controller questionnaires, and observer logs were used to evaluate the proposed operation performance in meeting the established test criteria.

Only data from blunders involving flight simulators as evading aircraft were used in the blunder resolution performance and NTZ entry analyses due to aerodynamic performance differences that have been identified between TGF aircraft and flight simulators. The TGF interface does not enable SPOs to respond in a manner that is representative of operational aircraft. In addition, SPOs are not actual line pilots. Both flight simulator and TGF aircraft were included in the NBO analysis, since NBOs were usually caused by TNSE, and the fidelity of the pilot/aircraft performance was not as critical as in the blunder resolution performance.

Two Monte Carlo computer simulations of parallel approach blunders were used after the real-time simulation to enhance the risk assessment part of the analysis. The test condition parameters were the same as for the real-time simulation. The Monte Carlo analyses used the recorded controller and aircraft response data as inputs to the models. The Monte Carlo TCV rate results were compared to the real-time TCV rate results to ensure they were compatible. The similarities and differences between the Monte Carlo simulations are detailed in Appendix B, and a description of the risk assessment methodology can be found in Appendix C.

In addition to the data available from the simulation, the MPAP TWG drew upon their understanding of the nature of daily operations, the knowledge and skills of controllers and pilots, and the full range of traffic contingencies to evaluate the pilot and controller communications workload and to develop their operational assessment of the proposed operation.

11. Simulation Results

It should be kept in mind that, like the output of all experimental evaluations, the results of this study should not be extrapolated to situations that contain variables other than those tested in this study.

11.1 Test Criterion Violation Review

No TCVs occurred in the real-time simulation. One blunder resulted in an aircraft miss distance of less than 500 ft, but was deemed invalid due to faulty equipment. The controller issued breakout instructions several times, but nothing was transmitted on the frequency. The equipment problem was verified through video and audio review of the controller monitor room, the PRM display, and the flight simulator site involved in the blunder.

11.2 Test Criterion Violation Rate and Risk Analyses

Three analyses were conducted to estimate the TCV rate. First, the real-time simulation data were used in the calculation of an at-risk TCV rate. Then, two fast-time Monte Carlo simulations, the BRM and the ASAT, were conducted to increase the sample size using the real-time data, thus providing more accurate estimates of the TCV rate. The confidence intervals were determined for each of the TCV rates and were compared to the test criterion rate of 6.8 percent. These analyses are discussed in the following sections.

11.2.1 Real-Time Simulation

Out of a total of 304 blunders initiated over the course of the real-time simulation, 284 were considered at-risk: 253 nonresponding and 31 responding. The observed TCV rate from the real-time simulation was 0.0 percent (0 TCVs/253 at-risk, nonresponding blunders). The 99-percent confidence interval was 0.0 to 2.1 percent. Thus, the population TCV rate would very likely be below the test criterion of 6.8 percent.

11.2.2 Monte Carlo Simulations

The following sections report the results of the BRM and the ASAT Monte Carlo simulations and how they compared to the maximum acceptable TCV rate. Although the Monte Carlo models used similar methodologies, each model had its own unique inputs and modeling techniques, which may have accounted for differences in the results. For details on the BRM and ASAT model configurations, see Appendix B.

11.2.2.1 Blunder Risk Model Results

The BRM Monte Carlo simulation executed 125,490 at-risk, nonresponding blunders that resulted in a TCV rate of 1.9 percent. The 99-percent confidence interval was 1.8 to 2.0 percent. The BRM Monte Carlo TCV rate was also below the test criterion maximum TCV rate of 6.8 percent.

The BRM TCV rate was calculated as a function of distance from the threshold for additional analysis purposes. Since the approach courses were offset radially, it was expected that the TCV rate would be greater closer to the runway threshold. The results are shown in Table 3. All values were still well below the maximum acceptable TCV rate of 6.8 percent.

Table 3. Blunder Risk Model Test Criterion Violation Rates as a Function of Distance from Runway Threshold

Range (nm)	9.5, 10.5, 11.5	7.5, 8.5	5.5, 6.5	3.5, 4.5	1.5, 2.5
Number of At-Risk Blunders	35,294	23,529	23,529	23,529	23,529
TCV Rate (percent)	0.9	0.9	3.1	2.8	2.2

Analysis of the BRM trials that resulted in TCVs showed that 11 evader tracks were responsible for 70 percent of the TCVs: 1 each in the range bins with 0.9 percent TCV rates and 3 each in the other range bins. These tracks were analyzed to determine the contributing factors that caused these pilot/aircraft evader responses to be less effective. These tracks shared a combination of the following traits: late and/or shallow response, aircraft motion towards the NTZ, and first transmission not received, thereby delaying the evader response.

11.2.2.2 ASAT Results

The ASAT Monte Carlo simulation executed 427,978 at-risk, nonresponding blunders that resulted in a TCV rate of 0.11 percent. The 99-percent confidence interval was 0.10 to 0.12 percent. The ASAT Monte Carlo TCV rate was also below the test criterion maximum TCV rate of 6.8 percent.

The ASAT TCV rate was also calculated as a function of distance from the runway threshold. Table 4 shows the results of this additional analysis. The ASAT TCV rates remained well below the maximum acceptable TCV rate of 6.8 percent at all points on the approach.

Table 4. ASAT Test Criterion Violation Rates as a Function of Distance from Runway Threshold

Range (nm)	10	8	6	5	4	3	2
Number of At-Risk Blunders	79,433	53,830	51,735	59,300	61,200	56,900	65,580
TCV Rate (percent)	0.014	0.050	0.070	0.080	0.120	0.190	0.247

The TCV rate estimates obtained from the Monte Carlo simulations corresponded with and thus supported the results obtained from the real-time simulation. Based upon these findings, the conduct of the tested procedure should not increase the risk of an accident above the target level of safety.

11.3 No Transgression Zone Entry and Nuisance Breakout Analyses

No NTZ entries were made by flight simulators that were not the result of a blunder or breakout. Therefore, the NTZ entry rate was acceptable.

A total of 22 NBOs occurred in the real-time simulation out of the 1,724 nonblunder-related approaches (1.3 percent). The TWG and technical observers agreed that the NBO rate was at an acceptable level.

11.4 Controller Communications Workload

The controller communications workload associated with TNSE-related events for the proposed operation was deemed satisfactory by participating controllers, controller technical observers, and the TWG. Since the number of NTZ entries and NBOs was not excessive, controllers were not overburdened with communications to aircraft flying the approaches.

11.5 Technical Work Group Operational Assessment

Based upon the test results, the TWG expertise and judgment, and evaluations from the controller and pilot technical observers, the TWG unanimously agreed that the procedure met all of the established criteria. The enhanced pilot and controller training procedures and the modified controller breakout phraseology clearly contributed to the success of the proposed operation.

Pilots were better trained on situational awareness and flight procedures than in the previous 3000-ft simulation. In addition, controllers were better trained on the use of the breakout phraseology and in the use of the FMA than in the previous simulation. The modified phraseology itself helped to reduce the number of blocked and clipped communications with the addition of the words "Traffic Alert" prior to the call sign announcement. The enhanced training procedures and phraseology affected overall system performance so that responsibilities were clearly understood, response times were improved, and adequate aircraft separation was maintained. Although the ABDs were not used in this simulation, they will be required in ground radios before implementation of this close parallel configuration. In the event that ABDs are not available, the air traffic facility will have two communication frequencies available for each close parallel runway, allowing the tower and monitor controllers to simultaneously broadcast on both frequencies to reduce the effect of blocked communications.

Although not tested in this simulation, the TWG recognized the need to address the missed approach procedure for the closely spaced operation. A separate study was done to evaluate the missed approach, which is described in Appendix M. As a result of the study, the TWG recommended that controller monitoring of the missed approach be required to ensure adequate separation of aircraft in the event of a simultaneous missed approach on the 3000 ft, 2.5-degree offset configuration.

The TWG unanimously agreed to recommend the tested procedure on simultaneous approaches to dual runways spaced 3000 ft apart using the PRM system with a 1.0 second update rate and a 2.5-degree localizer offset for approval in the operational environment.

11.6 Additional Analyses

The TWG had additional data available to them to refer to as necessary when evaluating the four test criteria. The following sections describe in detail the supplemental assessments and analyses that were performed.

11.6.1 Controller Technical Observer Assessment

During the simulation, the controller technical observers witnessed improvements in the problem areas identified during the previous 3000-ft simulation. Those problem areas were aircraft response times, communications, and phraseology.

Aircraft response times appeared to be faster. This may have been due to a combination of heightened awareness training and/or hand-flown breakout maneuvers. Regardless, the response times appeared to decrease significantly. Improved phraseology benefited the simulation in the area of communications and phraseology. The phrase "Traffic Alert" at the beginning of the

transmission not only alerted all pilots on the frequency to listen for an urgent message, but also ensured that if the beginning of the transmission was blocked, the aircraft call sign could still be heard.

The controller technical observers believed that improved controller training, as well as improved phraseology, played a significant role in the success of the simulation. Prior to participation in actual test runs, controllers attended a briefing consisting of information on the PRM system, the simulated airport environment (including airport layout, approaches, and minimum vectoring altitudes), and controller responsibilities. Also included in the briefing was an aircraft simulator cockpit video, which was shown to educate the controllers on what occurs after breakout maneuvers are issued. The briefing was instrumental in helping the controller make the most effective decision when issuing the breakout instruction, especially when a descending breakout instruction was involved. In addition to knowledge gained from the briefing, 8 hours on position and resolving blunders were required for each controller prior to participating in test runs.

The controllers appeared more relaxed during this simulation than in previous simulations, and conflicts were resolved with relative ease. After observing this simulation, the controller technical observers concluded that the 3000-ft, 2.5-degree localizer offset procedure could be conducted safely and efficiently in the operational environment as long as controllers were trained similarly to how they were trained in this simulation.

11.6.2 Pilot Technical Observer Assessment

Aircraft breakout performance was a function of the controller and pilot performance. The performance of the pilots was improved over the previous 3000-ft offset approach simulation. This improvement was probably due to the pilot awareness training, the new controller phraseology, the improved controller training, and the requirement to hand-fly the aircraft during the breakout maneuver. The effectiveness of each of these factors was not quantified in this simulation, but the importance of each can be addressed.

The pilot awareness training most likely contributed to a reduction of long response times by a number of pilots. After the training, the pilots were more aware of the dangers of not reacting promptly. The new phraseology, beginning with "Traffic Alert", resulted in fewer communication problems by reducing the number of clipped call sign transmissions and by alerting pilots to the fact that a breakout was imminent.

Controller training resulted in the controllers using one transmission for the evasion instruction instead of many. This gave pilots more time during a high workload period to accomplish duties associated with the breakout instead of answering air traffic controllers on the radio. The overall controller performance during this simulation improved over the previous simulation and contributed greatly to the aircraft breakout performance.

The hand-flown breakout requirement was effective in significantly reducing the time-to-turn during breakout maneuvers flown in the B747-400 simulator. This improvement will vary between various types of glass cockpit aircraft because of autopilot system design differences.

There was almost no measurable improvement in less sophisticated aircraft such as the B727, because the breakout would most likely be flown manually even without the requirement.

11.6.3 Closest Point of Approach Distribution Analyses

Although no TCVs occurred during the simulation, the distribution of CPAs was examined to provide information on the degree of separation maintained for all WCBs involving flight simulators. Figure 5 shows that the mean separation for at-risk blunders was 2,358.91 ft, with a standard deviation of 842.06 ft. The range of CPAs was from 514.00 ft to 4,467.00 ft. CPAs were also sorted by simulator type and examined. Table 5 details the results.

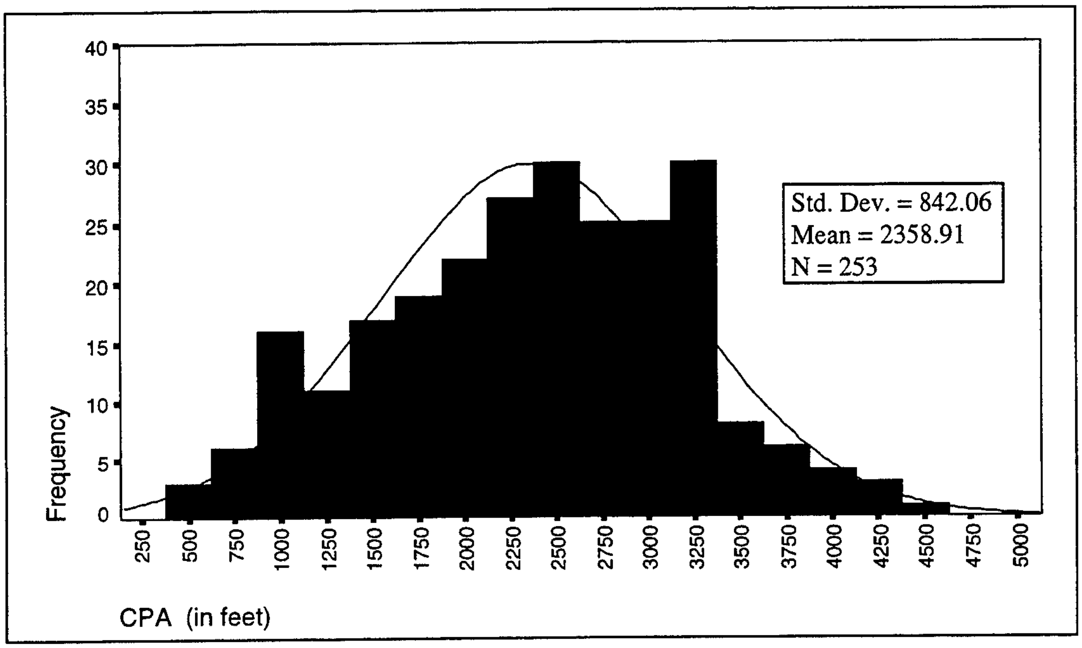


Figure 5. Closest point of approach distribution for all worst-case blunders.

Table 5. Closet Point of Approach by Simulator Type

SITE	SIMULATOR TYPE	MEAN CPA (ft)	STANDARD DEVIATION (ft)	NUMBER OF CASES
AVIA	B727	2654.67	905.04	63
DELTA	MD90	2272.85	872.56	80
GAT	C421	2235.84	695.77	14
NASA	B747-400	2273.03	776.09	76
OKCITY	B727	2183.80	680.84	20

11.6.4 Response Time Analyses

11.6.4.1 Controller Response Time Analyses

Controller response times for all blunders were determined (i.e., 299 blunders; response times not able to be extracted from 5 blunders). The times were calculated from the time of the alert onset (i.e., the change in color of the predictor line and data block from green to yellow) to the time the controller keyed the microphone to communicate with the pilot of the evading aircraft. Response times ranged from -3 seconds to 3 seconds (with one outlier response time of 10 seconds). The mean response time for all blunders was 0.5 seconds with a standard deviation of 1.1 seconds. Only positive response times collected from the real-time simulation were used in the Monte Carlo simulations. Figure 6 depicts the complete frequency distribution of controller response times, which were independent of blunder range from threshold.

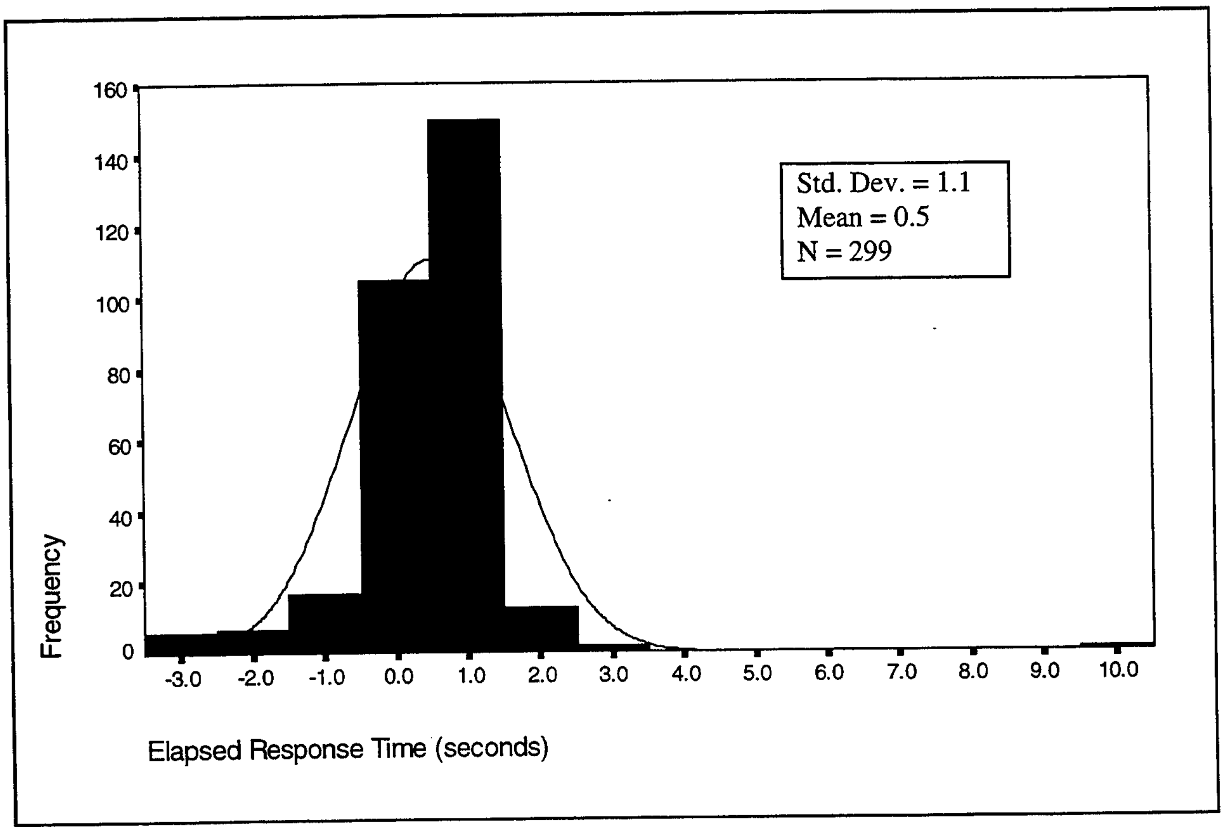


Figure 6. Controller response times for all blunders.

11.6.4.2 Pilot/Aircraft Response Time Analyses

Pilot/aircraft response times for the evaders were extracted using data collected at the flight simulator sites. The pilot/aircraft response was measured as elapsed time from the beginning of the evader controller transmission to a particular event (e.g., attainment of 3 degrees of roll, increase in engine pressure ratio). This analysis focuses on the time to attainment of 3 degrees of roll because the promptness of the turning response appears to be the most critical in assuring separation of aircraft during a blunder scenario.

NOTE: During post-simulation analyses, it was noted that the pilot/aircraft response times observed in the cockpit simulator videotapes appeared to be 2 to 3 seconds faster than the response times derived from the data. Initial investigation revealed a delay in the data (both time and position) on the PRM display, most likely due to delays in the network and the simulated PRM. While further investigation is necessary to confirm the source(s) of the delays and to find more precise figures for them, one can consider the results of the simulation to be conservative. The pilot/aircraft responses in this section have not been adjusted for the delays, but could be approximately 1.5 to 2.5 seconds less than the times indicated (0.5 seconds was subtracted from 2 to 3 seconds because the specifications of the production system include a maximum delay of 0.5 seconds).

Data for the roll response times (times to attainment of 3 degrees of roll) were available for most of the evasions with the exception of 27 from the NASA B747 site and 5 from the Oklahoma City B727 site. Roll response times were also not available for five GAT evasions because those aircraft were already in a roll in the direction of the evasion maneuver when the evader controller began transmitting.

The distribution of roll response times for the simulation are shown in Figure 7.

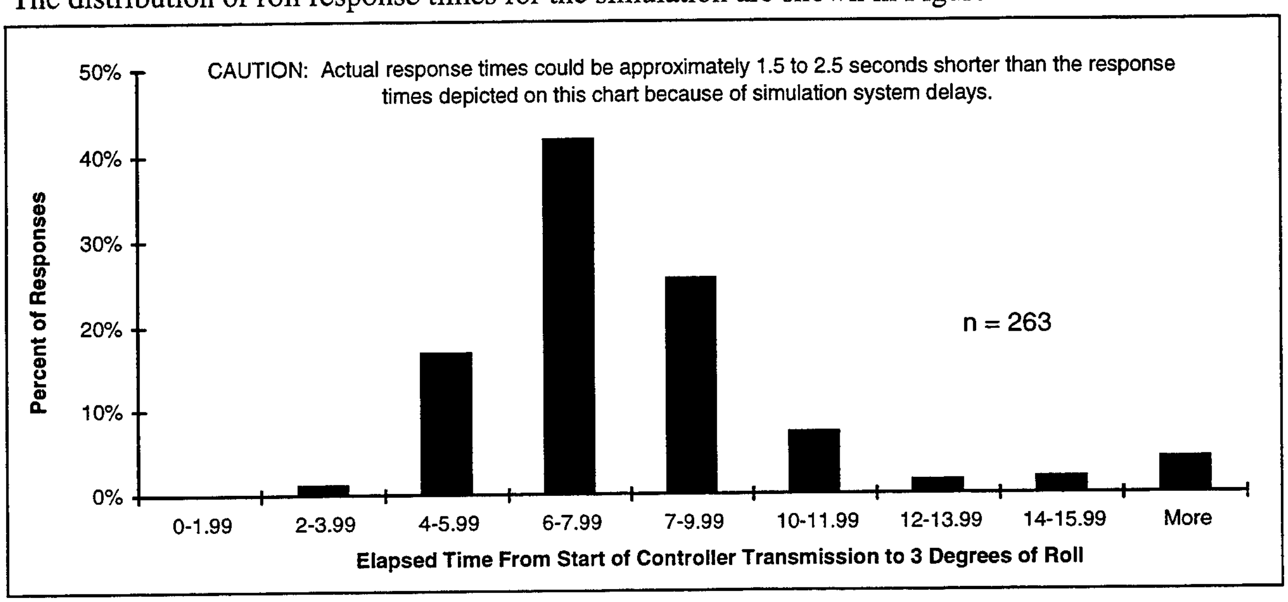


Figure 7. Roll response times - all flight simulator sites.

As can be seen in the figure, nearly 60 percent of the roll response times were less than eight seconds. Further, the data indicated only small differences among the flight simulator sites. A breakdown of roll response time statistics by simulator site is shown in Table 6. The aggregate statistics for all sites is also in Table 6.

Table 6. Roll Response Time Statistics

CAUTION: Actual response times could be approximately 1.5 to 2.5 seconds shorter than response times depicted on this chart because of simulation system delays.

	AVIA B727	Delta MD90	GAT	NASA B747	OKC B727	All Sites
Median Time to 3 Degrees Roll	7	8	6	8	7	8
Mean Time to 3 Degrees Roll	7	9	7	9	8	8
Minimum Time to 3 Degrees Roll	4	4	3	4	4	3
Maximum Time to 3 Degrees Roll	19	19	18	32	18	32
Number of Breakouts	72	95	10	62	24	263

Analysis of the data collected at the simulator sites also revealed that, for 21 evasions at the Delta MD90 simulator site, pilots elected to execute the breakout using the autopilot, contrary to their training for the simulation. A breakout was considered to be executed on the autopilot if 3 degrees of roll was attained before the autopilot was disengaged. The roll response time distribution for the 21 autopilot breakouts (Figure 8) shows slower roll response times than in the aggregate distribution in Figure 7. For information on additional aircraft breakout performance results, see Appendix L.

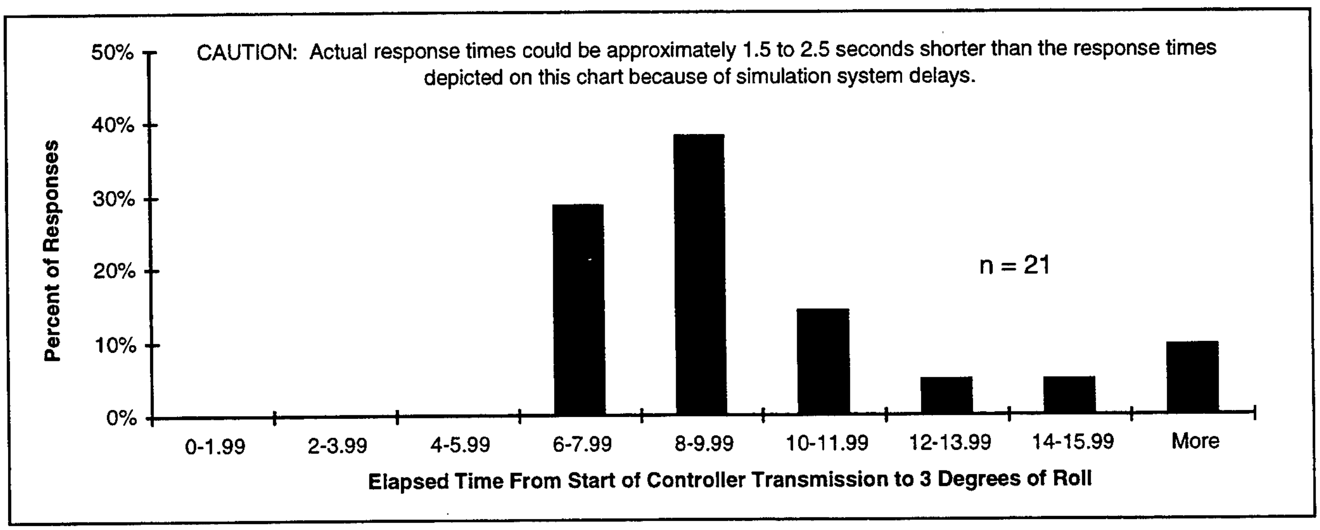


Figure 8. Roll response times for autopilot breakouts (MD90).

11.6.5 Controller Breakout Instruction Content Analyses

All controller breakout instructions made during the simulation were studied in detail for content and delivery. Use of standard phraseology and the number of transmissions required to complete breakout instructions were two components of the messages that were analyzed. In addition, the number of descending breakout instructions and the number of blocked or clipped communications was determined.

11.6.5.1 Use of Standard Phraseology and Standard Altitudes and Headings for Runways

Controllers were briefed on the standard phraseology to use in the event of a blunder (see Section 7.1.1), and had an opportunity to rehearse the phraseology during practice runs. During actual test runs, most controllers used the standard phraseology in the initial breakout instructions, although they were not required to do so. Furthermore, most used the standard altitudes and headings assigned to particular localizer courses and runways. However, variations in phraseology did occur. Table 7 shows the frequencies and subsequent percentages of the use of standard and nonstandard phraseology over the course of the simulation.

Table 7. Use of Standard Breakout Phraseology and Standard Altitudes/Headings for Runways

		Standard Altitudes/Headings for 3000-Ft Configuration (in 1st Transmission)	
		Used	Did Not Use
Standard Phraseology (in first transmission)	Used	263 (87.7 percent)	22 (7.3 percent)
	Did Not Use	11 (3.7 percent)	4 (1.3 percent)

During 87.7 percent of the blunder events, controllers used the standard phraseology and the standard altitudes and headings assigned to particular runways in the initial breakout transmission. During 7.3 percent of the blunders, controllers used the standard phraseology, but assigned nonstandard headings and altitudes. During 3.7 percent of the blunders, controllers did not use the standard phraseology (e.g., forgot to say "Traffic Alert" or assigned only a heading), but did use the standard altitudes and headings assigned to particular runways. Finally, during 1.3 percent of the blunders, controllers did not use the standard phraseology and did not use the standard altitudes and headings.

11.6.5.2 Multiple Transmissions

The number of transmissions made by the controller in directing an aircraft to break out of an approach was also examined. In 67.1 percent of the blunder events, controllers completed the breakout instructions in one transmission. In the remaining 32.9 percent of the blunder events, controllers transmitted two, three, and four times (i.e., multiple transmissions) to evading aircraft. The breakdown by number of transmissions is shown in Figure 9.

The multiple transmissions were categorized by the contents of the subsequent transmissions. There were several reasons for the multiple controller transmissions. First, 33 percent were repeats of the initial breakout instructions. In most of these cases, controllers repeated breakout instructions because pilots of the evading aircraft did not verbally respond directly following the messages, and the controllers thought their messages were not received. In other cases, controllers repeated breakout instructions as a means of emphasizing the urgency of the situation.

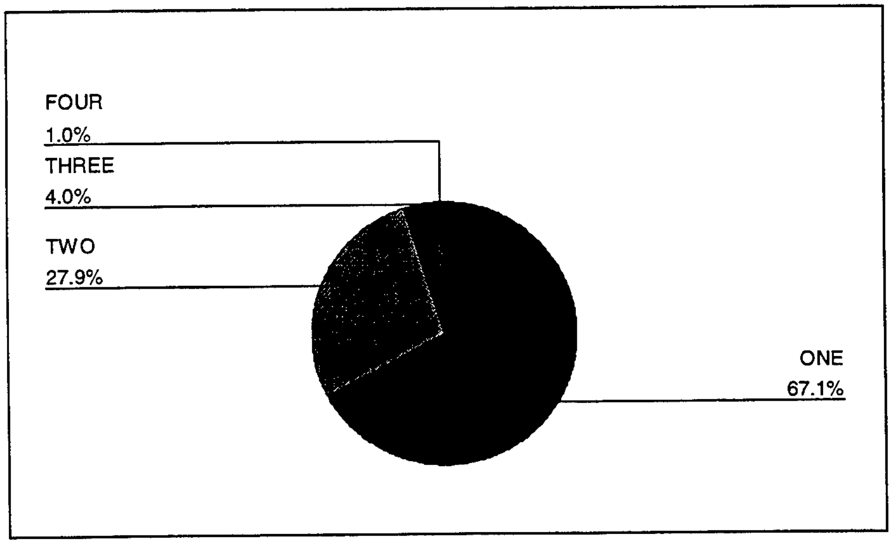


Figure 9. Number of transmissions required to complete breakout instructions for all blunders.

A further 32 percent of the multiple transmissions were to offer additional information to the pilots. This information included phrases such as: "Best rate of climb/turn," "No delay in your turn/climb," "Expedite your turn/climb," "Tighten up your turn," "Traffic's deviating off your left/right off the other localizer," and "Traffic's less than a mile."

Fifteen percent of the multiple transmissions were for changes to initial instructions. All of the changes were to headings. Controllers first issued standard breakout headings of either 090 degrees or 270 degrees, then came back and changed them to greater turns, such as to 040 or 300 degrees.

Ten percent of the multiple transmissions were for combinations of types of information (repeat, additional, change, and split) within a transmission, as follows:

- 5.1 percent: repeat and additional information
- 3.4 percent: change and additional information
- 0.8 percent: change and repeat
- 0.8 percent: change and split (split means the controller only gave the turn in the initial instruction, and gave the altitude in one of the following transmissions)

The rest of the multiple transmissions (9 percent) consisted of questions to evading aircraft pilots who offered no verbal response following breakout instructions such as, "Delta 625?" and

"American 799, how do you hear me?" The transmissions also consisted of confirmatory statements, such as, "That's correct," and "That's affirmative," and appreciative statements, such as, "Thank you," and "Excellent turn."

11.6.5.3 Descending Breakout Instructions

No descending breakout instructions were issued by controllers during the simulation. All controllers were briefed on the standard breakout phraseology, which included a climb instruction. However, they were still given the option to issue instructions as they deemed appropriate (see Section 3.2.3). Nevertheless, no controllers opted to descend aircraft off the localizer courses.

11.6.5.4 Blocked and Clipped Breakout Instructions

A total of 418 breakout-related ATC transmissions were made over the course of the simulation. Of those transmissions, 13 were either blocked or clipped (3.1 percent), with the majority being clipped.

Six of the blocked/clipped transmissions occurred during the controller's initial breakout instruction. In three of these cases, the phrase "Traffic Alert" was clipped. However, the rest of the instructions were not clipped, and therefore pilots were able to respond in a timely manner. In the other three cases, the controllers decided to repeat the instructions because they did not hear pilot readbacks following the initial transmissions.

Seven of the blocked/clipped transmissions occurred during the second ATC transmissions (transmissions following the initial breakout instructions). The effects were little to none because the instructions in all cases were repeats of the initial instructions, which were transmitted without interference the first time.

11.6.6 Questionnaire Analyses

11.6.6.1 Controller Questionnaire Analyses

Controllers were administered questionnaires at the end of each day and upon completion of their participation in the simulation. They were not informed of the results of their participation or of the simulation as a whole prior to completing the questionnaires.

11.6.6.1.1 Controller End-of-Day Questionnaires

Controllers rated stress levels, mental effort, and activity levels experienced throughout an entire day on the End-of-Day Questionnaire. All questions were answered on a scale from 1 (minimal) to 5 (intense). Stress was defined as anxiety, frustration, and/or pressure experienced in remaining alert when working with the PRM system and while re-establishing separation during a blunder. Mental effort was defined as concentration, attention, and/or decision making involved in trying to maintain vigilance and in detecting and resolving blunders. Activity was defined as frequency of actions and time spent on tasks due to the occurrence of blunders and traffic density. Forty-two questionnaires were completed and the results are reported in Table 8.

Table 8. Summary of Controller End-of-Day Questionnaire Responses

Rate the level of...	1 MINIMAL	2	3 MODERATE	4	5 INTENSE
Stress experienced in resolving blunders	17 percent	33 percent	38 percent	7 percent	5 percent
Stress experienced during the entire day	19 percent	58 percent	21 percent	2 percent	0 percent
Mental effort required to detect blunders	0 percent	29 percent	37 percent	29 percent	5 percent
Mental effort required to resolve blunders	14 percent	43 percent	31 percent	5 percent	7 percent
Mental effort required during the entire day	10 percent	38 percent	45 percent	7 percent	0 percent
Activity required during the entire day	9 percent	43 percent	43 percent	5 percent	0 percent

11.6.6.1.2 Post-Simulation Controller Questionnaire

Each controller was given a Post-Simulation Questionnaire at the end of his participation in the simulation. Questions addressed the feasibility of the tested procedure in the operational environment and the associated strategies that were developed to resolve blunder situations.

The results indicated that all of the controllers (100 percent) were supportive of the procedure as tested. They believed simultaneous approaches to runways spaced 3000 ft apart with one localizer offset by 2.5 degrees could be conducted safely. Additional comments addressed the need to train controllers and aircrews, particularly for the close parallel operation. Several controllers commented positively on the effectiveness of the standard breakout phraseology (i.e., Traffic Alert, aircraft call sign, turn left/right heading (degrees), climb and maintain [altitude]).

Controllers' suggestions for improvements to the procedure included requiring standard breakout procedures, slanting the radar scopes, and incorporating flashing TAs on the target data blocks. One controller commented that the radio equipment "must be able to block out pilot radio transmissions."

Controllers were asked to assess the communications workload for breakouts and NTZ entries relative to current operations. Three controllers rated the workload as less than current operations. Five rated it equal to, two rated it greater than, and two rated it much greater than current operations. One controller commented that it took more time to use the phrase "Traffic Alert"; another controller stated that the phraseology was better than current required phraseology.

Controllers were also asked if they had developed any specific control strategies for the simulated approach operation. Most controllers agreed that scanning techniques and prioritizing viewing areas were most important. The areas included scanning both finals and being alert for the aircraft flying side by side, paying particular attention to aircraft inside the outer marker,

and/or scanning for predictor lines. Other strategies mentioned involved inter-controller coordination strategies, such as listening to the other controller's altitude and turn assignments before transmitting and alerting the other controller of a blunder, especially if the blunderer was nonresponding.

The controllers were then asked if the strategies they developed were specific to the tested operation. Seven controllers said yes and five controllers said no. Three of the five controllers who said no stated that the strategies were not specific because they use them in the field now.

Controllers were asked to rate the adequacy of the briefing information and training they received prior to the actual test runs. All controllers commented that the briefing information was helpful, but the practice runs and the experience gained through the practice were the most important part of the training. One controller thought even more training on breakout procedures would have been helpful.

11.6.6.2 Pilot Questionnaire Analyses

At the end of their participation in the simulation, all 51 flight simulator pilots completed Flight Crew Opinion Surveys. These surveys covered the importance of the training materials, the information page, the additions to the approach plates, and the new phraseology. All pilots were encouraged to add written comments.

11.6.6.2.1 Preferred Method of Flying Approaches

The pilots were asked how they would fly a simultaneous close parallel approach. This information can be used in future simulations to assign a realistic ratio of hand-flown flight director and coupled autopilot (A/P) approaches. The B727 and glass cockpit pilots had similar opinions. Eighty-one percent preferred a coupled autopilot approach, as shown in Figure 10. Only 40 percent of the GAT pilots preferred a coupled autopilot approach, while 50 percent preferred hand-flying the aircraft during the approach.

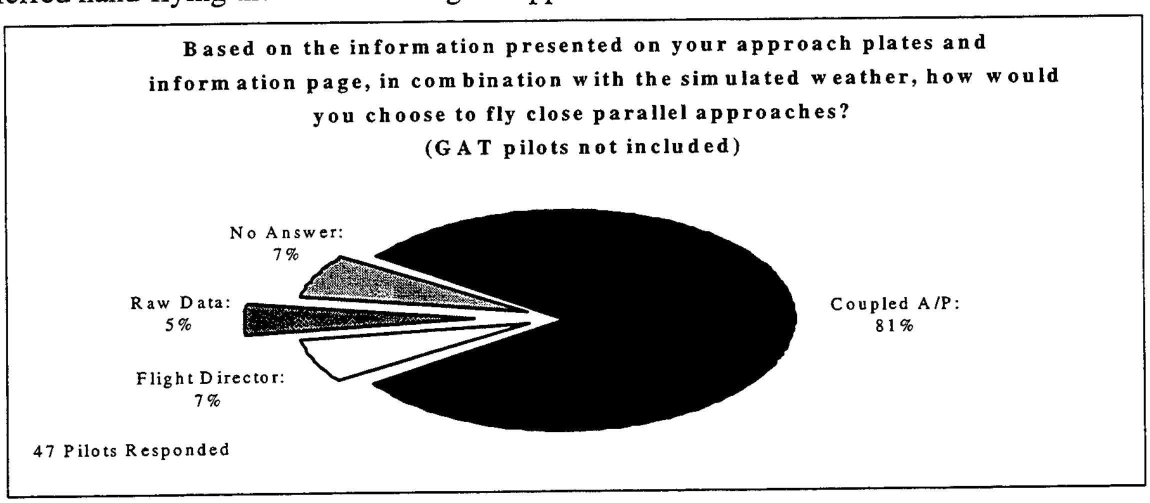


Figure 10. Preferred method of flying close parallel approaches.

11.6.6.2.2 Amount of Crew Coordination Required

It was important to ascertain how the pilots felt about crew coordination for the establishment of future training requirements. Most pilots agreed, as shown in Figure 11, that more crew coordination was required for simultaneous approaches than for normal approaches.

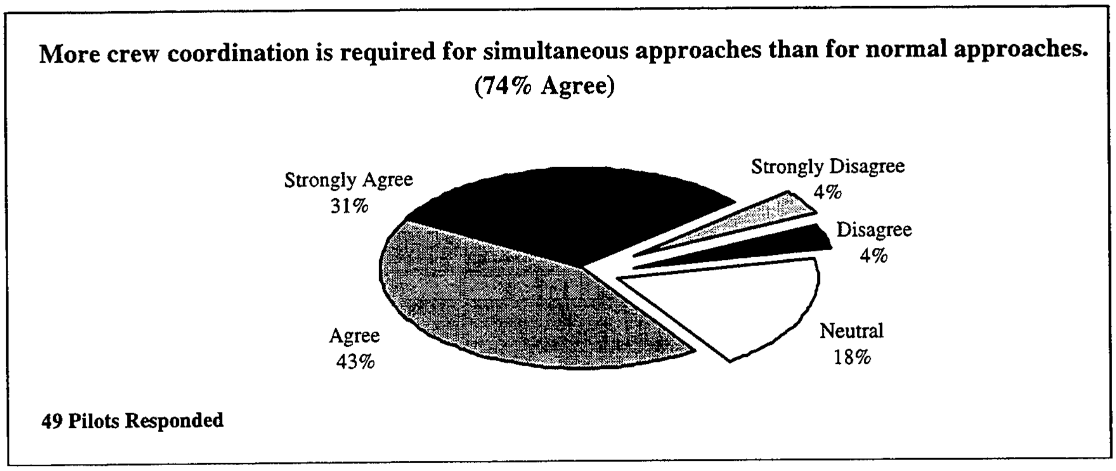


Figure 11. Crew coordination for close parallel approaches as compared to normal approaches.

11.6.6.2.3 Increased Awareness Through the Airport Information Page

Many changes were made to the airport information page. The pilots were asked questions regarding how these changes affected their awareness of adjacent aircraft and of close parallel approach procedures. The majority of pilots thought that their awareness was increased in both areas, as shown in Figures 12 and 13.

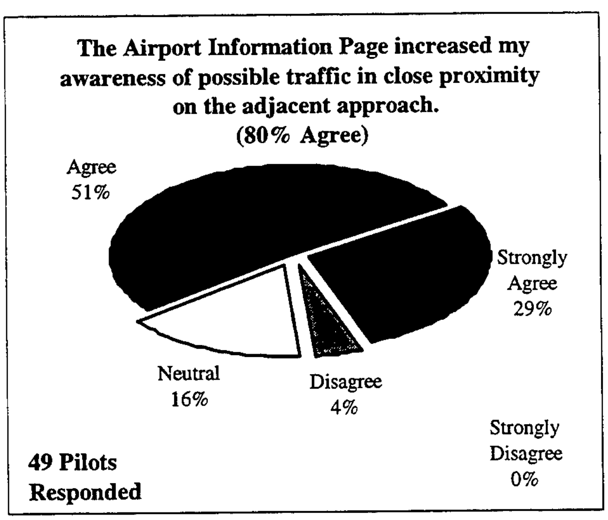


Figure 12. Airport information: Awareness of adjacent aircraft.

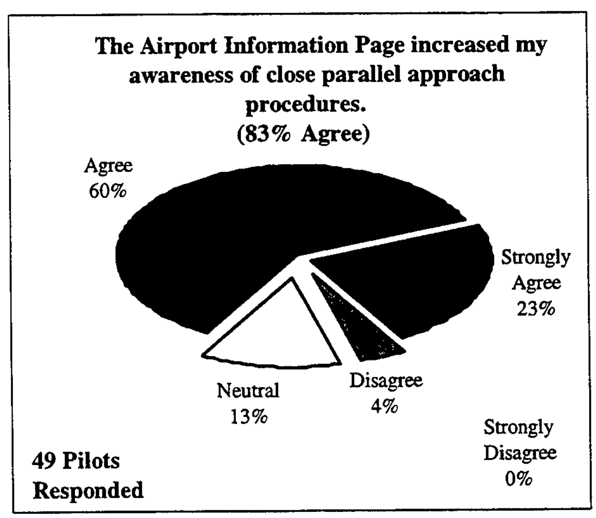


Figure 13. Airport information: Awareness of procedures.

11.6.6.2.4 New Air Traffic Control Phraseology

The simulation used new controller phraseology in the issuance of breakout instructions (refer to Section 6.1.1). It was important to learn of the pilot's reaction to this new phraseology and to determine the degree to which the pilots thought it was effective. The data in Figure 14 show that seventy-six percent of the pilots surveyed thought the new phraseology was more effective than the previous phraseology.

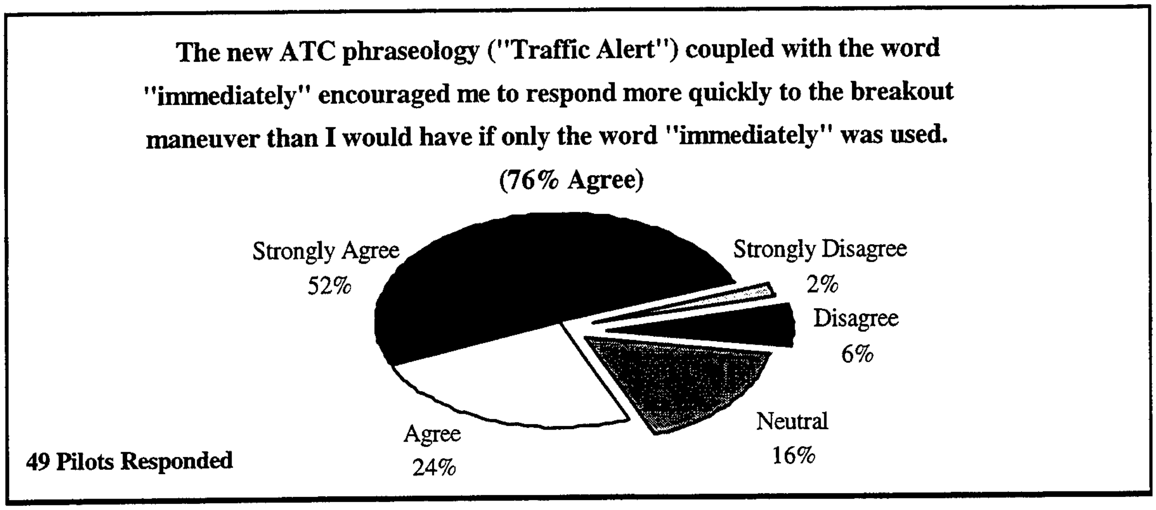


Figure 14. New air traffic control phraseology in relation to the production of faster pilot response times.

11.6.6.2.5 Increased Awareness Through Video

The video, RDU Precision Runway Monitor: A Pilots' Approach, was considered to be an important part of the pilot training. As illustrated in Figure 15, 83 percent of the pilots agreed to the statement, "The video increased my awareness of simultaneous close parallel approach operations."

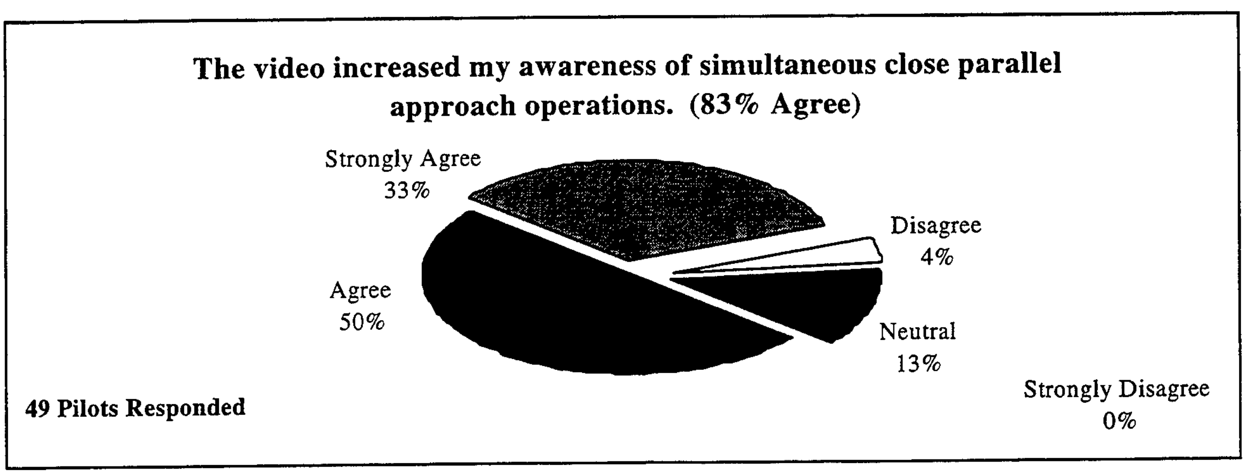


Figure 15. Video in relation to increased operational awareness.

11.6.6.2.6 Effect of Pilot Bulletins on Performance

Two questions addressed the effectiveness of the training bulletins. The first question asked the pilots whether or not the bulletins provided a better understanding of what was expected of them during the simultaneous close parallel approaches. The data in Figure 16 show that 77 percent of the pilots agreed the bulletins increased their understanding of the procedure. The second question asked the pilots if the training bulletins helped them to execute ATC-directed breakout maneuvers. The data in Figure 17 show that 59 percent of the pilots agreed that the training bulletins aided in the execution of breakouts.

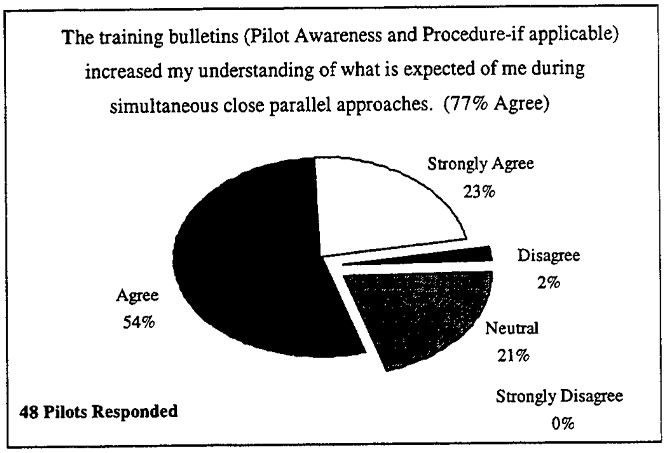


Figure 16. Pilot training bulletin: Understanding.

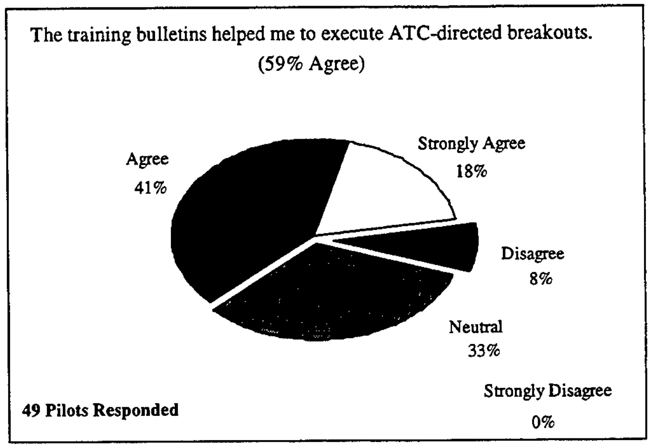


Figure 17. Pilot training bulletin: Execution.

11.6.6.2.7 No Descending Breakout Altitude

For this simulation, a note was incorporated into the approach plate that indicated the altitude on the approach below which no descending breakouts would be issued by the controller. A question was asked to determine whether or not this note was important to the pilots. Figure 18 confirms the importance of this item and illustrates that 73 percent of the pilots agreed that they were better prepared for the possible breakout. It should be noted that there were no descending breakouts issued during this simulation.

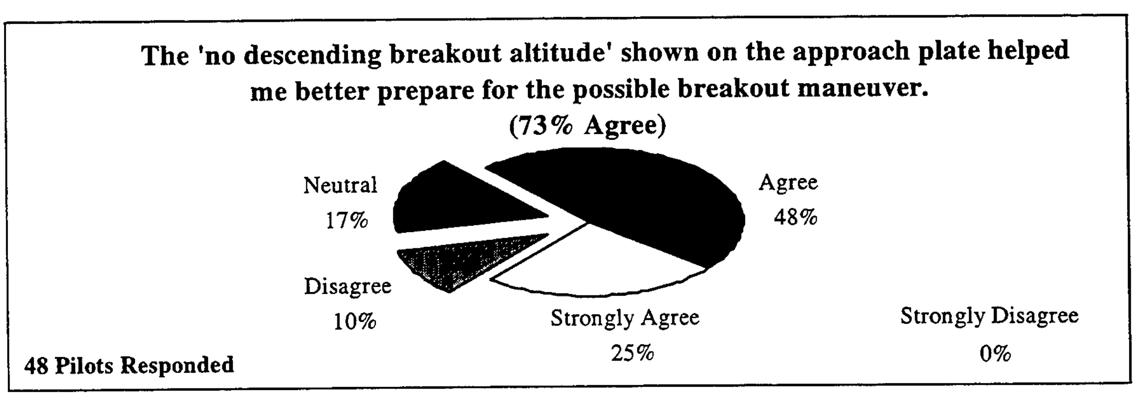


Figure 18. No descending breakout altitude on approach plate.

11.6.6.2.8 Rank of Importance

The last survey question asked the pilots to rate the importance of items used during the simulation. The significance of this question was that it rated the importance of each to the pilot. The most important item according to the pilots was the use of the phraseology, "Traffic Alert". More than half of the pilots rated this item as a 10. The responses to this question are depicted graphically in Figure 19.

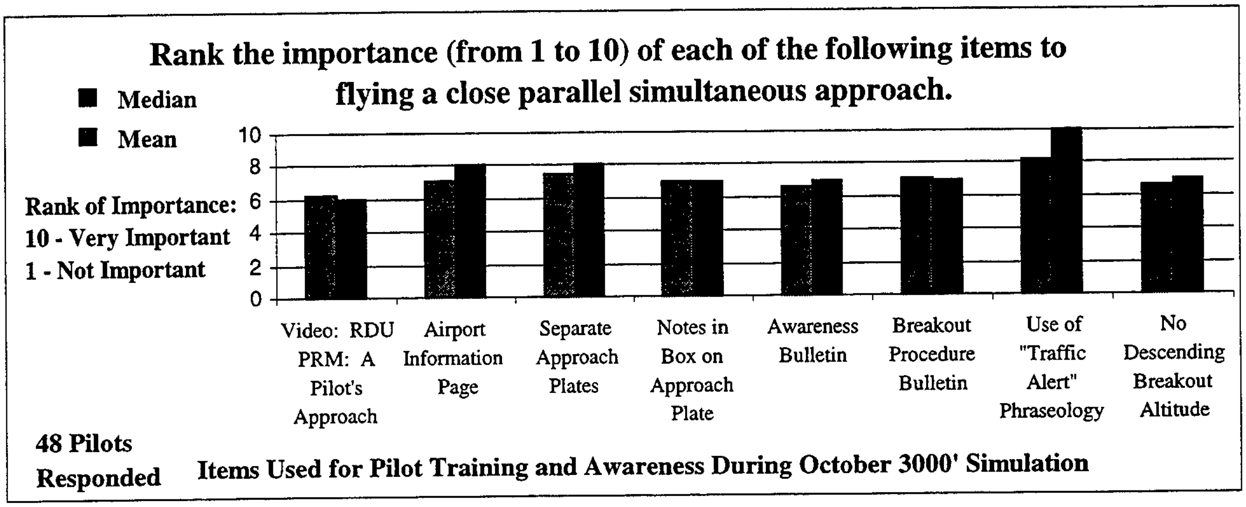


Figure 19. Rank of importance of items to flying a close parallel approach.

12. Summary

In the previous 3000-ft, 2.5-degree localizer offset simulation, the following three problem areas were identified that prevented the procedure from being recommended:

a. Pilot/aircraft response times and performances were inadequate to meet the target level of safety defined in the test criteria.

b. Blocked and clipped communications contributed to the severity of many conflicts.

c. Controller breakout phraseologies and procedures varied in content and duration, sometimes resulting in split transmissions and confusion in the cockpit.

The TWG formed investigative groups to determine ways to improve the three problem areas. It was recognized that procedure changes would be needed before the 3000-ft, 2.5-degree localizer offset operation could be recommended. The results of the pilot training and controller training groups' efforts were enhanced training packages designed to increase user awareness and improve performance during the conduct of the closely spaced approach operation.

As a result of the communications group's efforts, it was decided that, in implementing this close parallel configuration, ABDs shall be required in the ground radios. In the event ABDs are not available, the air traffic facility will have two communication frequencies available for each close parallel runway, allowing the tower and monitor controllers to simultaneously broadcast on both frequencies to reduce the effect of blocked communications.

All of the TWG's established test criteria were met in the October 1995 3000-ft simulation. The real-time TCV rate was 0.0 percent, with an upper confidence limit for the true value of 2.1 percent. Using the response data from the study, the BRM and ASAT Monte Carlo simulations had observed TCV rates of 1.9 percent and 0.11 percent, respectively, with upper confidence limits of 2.0 percent and 0.12 percent, respectively. These results were considerably less than the maximum acceptable TCV rate of 6.8 percent. In addition, there were no unintended entries into the NTZ by flight simulators, and only 22 NBOs (1.3 percent) caused by normal flight behavior. Both results were considered to be acceptable frequencies by the TWG. Controller communications workload was also determined to be acceptable.

13. Conclusions

This simulation tested the procedure for simultaneous ILS approaches to two parallel runways spaced 3000 ft apart with one localizer offset by 2.5 degrees, using the PRM system with a 1.0-second update rate. The MPAP TWG evaluated both controller and pilot effectiveness at resolving conflicts, the frequency of NTZ entries and NBOs, and the ability of the system to support a target level of risk of no more than one fatal accident per 25,000,000 approaches. Based upon their observations and evaluations, the TWG recommends this procedure as tested for approval in the operational environment.

Glossary

At-Risk Blunder - (As defined for this simulation) A blunder in which two aircraft would have come within 500 ft of one another without controller intervention.

Blunder - (As defined for this simulation) An unexpected turn by an aircraft already established on the localizer toward another aircraft on an adjacent approach.

Breakout - A technique used to direct aircraft out of the approach stream. In the context of close parallel operations, a breakout is used to direct an aircraft away from a deviating aircraft while simultaneous operations are being conducted.

Close Parallels - Two parallel runways whose extended centerlines are separated by at least 3,400 feet, but less than 4,300 feet, and having a Precision Runway Monitoring (PRM) system that permits simultaneous independent ILS approaches. (FAA, 1995a) (Pending change)

Closest Point of Approach (CPA) - (As defined for this simulation) The smallest slant range distance between two aircraft involved in a conflict. The distance is measured from the center of each aircraft.

Confidence Interval - A statistically defined range of values of the population mean, any one of which is likely to be represented by the sample means.

Conflict - (As defined for this simulation) An event in which two or more aircraft approach each other with less than the minimum allowable airspace separation. A conflict occurs if there is less than 1000 ft vertical or 3 nm horizontal distance between aircraft, unless the aircraft are established on ILS approaches and separated by an NTZ during simultaneous ILS approaches.

Controller Technical Observer - An individual who observes a monitor controller position during each simulation run. Duties include documenting discrepancies between issued control instructions and actual aircraft responses; assisting in alerting responsible parties to correct any problems that may occur during the test (e.g., computer failure, stuck microphone); assisting controllers in preparation of reports; and documenting their evaluation of the data in a technical observer assessment at the end of the simulation.

CPA prediction tool - A software tool used by the simulation test director that presents a window of aircraft alignments for predicting separation between aircraft.

Final Monitor Aid (FMA) - A high resolution color display that is equipped with the controller alert system hardware and software used in the PRM system. The display includes alert algorithms providing the target predictors, a color change alert when a target penetrates or is predicted to penetrate the NTZ, a color change alert if the aircraft transponder becomes inoperative, synthesized voice alerts, digital mapping, and like features contained in the PRM system (FAA, 1995a; FAR, 1995).

Final Monitor Controller - Air Traffic Control Specialist assigned to radar monitor the flight paths of aircraft during simultaneous parallel and simultaneous close parallel ILS approach operations. Each runway is assigned a final monitor controller during simultaneous parallel and simultaneous close parallel ILS approaches. Final monitor controllers shall utilize the Precision Runway Monitor (PRM) system during simultaneous close parallel ILS approaches. (FAA, 1995a).

Flight Technical Error (FTE) - (As defined for this simulation) The accuracy with which the pilot controls the aircraft as measured by the actual aircraft position with respect to the desired aircraft position. It does not include blunders.

Glide Slope Intercept Altitude - The minimum altitude to intercept the glide slope/path on a precision approach. The intersection of the published intercept altitude with the glide slope/path, designated on Government charts by the lightning bolt symbol, is the precision Final Approach Fix (FAF); however, when ATC directs a lower altitude, the resultant lower altitude intercept position is then the FAF. (FAA, 1995a; FAR, 1995)

Indicated Airspeed (IAS) - The speed shown on the aircraft airspeed indicator. This is the speed used in pilot/controller communications under the general terms, airspeed. (FAA, 1995a; FAR, 1995)

Instrument Landing System (ILS) - A precision instrument approach system which normally consists of the following electronic components and visual aids: localizer, glide slope, outer marker, middle marker, and approach lights. (FAA, 1995a; FAR, 1995)

Instrument Meteorological Conditions (IMC) - Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling less than the minima specified for visual meteorological conditions. (FAA, 1995a; FAR, 1995)

Localizer Offset - An angular offset of the localizer from the extended runway centerline in a direction away from the No Transgression Zone (NTZ) that increases the Normal Operating Zone (NOZ) width. An offset requires a 50 foot increase in decision height (DH) and is not authorized for CAT II and CAT III approaches (FAA, 1995a).

Mean - The arithmetic average; or the sum of measurements divided by the total number of measurements.

Median - The middle value when measurements are arranged in order of magnitude; the value at the 50th percentile of a set of measurements.

Multiple Parallel Approach Program Technical Work Group (MPAP TWG)- A group of FAA employees representing several different offices (e.g., Secondary Surveillance Product Lead, Office of System Capacity and Requirements) that assembles to make recommendations on multiple parallel approach procedures.

National Airspace System (NAS) - The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information and manpower and material. Included are system components shared jointly with the military. (FAA, 1995a; FAR, 1995)

No Transgression Zone (NTZ) - A 2000 foot wide zone, located an equal distance between parallel runway final approach courses, in which flight is not allowed (FAA, 1995a).

Normal Operation Zone (NOZ) - The operating zone within which aircraft flight remains during normal independent simultaneous parallel ILS approaches (FAA, 1995a).

Nuisance Breakout (NBO) - (As defined for this simulation) An event in which an aircraft is broken out of its final approach for reasons other than a blunder, loss of longitudinal separation, or lost beacon signal (i.e., aircraft goes into coast).

Outer Marker (OM) - A marker beacon at or near the glide slope intercept altitude of an ILS approach. It is keyed to transmit two dashes per second on a 400 Hz tone, which is received aurally and visually by compatible airborne equipment. The OM is normally located four to seven miles from the runway threshold on the extended centerline of the runway. (FAA, 1995a; FAR, 1995)

Pilot Technical Observer - A pilot who participates in the simulation as a flight simulator site coordinator. The pilot technical observer evaluates operational aspects of the simulation at the sites and is the conduit to the William J. Hughes Technical Center for that area/phase of the simulation.

Precision Runway Monitor (PRM) System - A system that provides air traffic controllers with high precision secondary surveillance data for aircraft on final approach to closely spaced parallel runways. High resolution color monitoring displays (FMAs) are required to present surveillance track data to controllers along with detailed maps depicting approaches and the no transgression zone. (FAA, 1995a; FAR, 1995)

Simulation Pilot Operator (SPO) - A person who operates a Target Generation Facility (TGF) computer workstation and controls the trajectory of TGF aircraft by computer input messages. The SPO usually communicates via voice circuits to ATC personnel in the laboratory that is being used to simulate an operational facility.

Simultaneous ILS Approaches - An approach system permitting simultaneous ILS/MLS approaches to airports having parallel runways separated by at least 4,300 ft between centerlines. Integral parts of the total system are ILS/MLS, radar, communications, ATC procedures, and appropriate airborne equipment. (FAA, 1995a; FAR, 1995)

Site Coordinator - A current or retired airline pilot with MPAP real-time simulation and flight simulator experience who observes aircrews during their approaches. Duties include briefing aircrews, providing pilots with flight information, documenting approach information, and administering questionnaires to the pilots.

Target Generation Facility (TGF) - An advanced simulation system designed to support testing of current and future ATC systems at the William J. Hughes Technical Center. The TGF is capable of modeling a logical view of the ATC environment (airspace volume including geographic data, weather data, navigation aids, radar sensors, airport data, and air routes) as well as simulating dynamic data associated with the movement and control of aircraft through the selected airspace.

Target Generation Facility (TGF) Aircraft - Targets generated by the TGF at the William J. Hughes Technical Center. TGF aircraft are used to provide additional traffic and to initiate blunders.

Test Criterion Violation (TCV) - (As defined for this simulation) An event that occurs when the CPA between two aircraft after the initiation of a blunder is less than 500 ft.

Test Director - The individual responsible for cueing blunder initiation through the use of the CPA prediction tool and by assessing the blunder scripts. The test director is the liaison between the William J. Hughes Technical Center and the flight simulator sites during the simulation.

Total Navigation System Error (TNSE) - (As defined for this simulation) The difference between the actual flight path of the aircraft and the path it is intending to fly. It is caused by FTE, avionics error, ILS signal error, and weather.

Worst-Case Blunder (WCB) - (As defined for this simulation) A blunder in which the blundering aircraft turns 30 degrees towards an adjacent approach course and does not respond to controller instructions to return to course.

Acronym List

ABD	Anti-Blocking Device
ASAT	Airspace Simulation and Analysis for TERPS
ATC	Air Traffic Control
ATIS	Automatic Terminal Information System
BRM	Blunder Risk Model
CPA	Closest Point of Approach
DH	Decision Height
E-Scan	Electronic Scanning
EI	External Interface
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FMA	Final Monitor Aid
FTE	Flight Technical Error
GAT	General Aviation Trainer
IAS	Indicated Airspeed
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Initial Point
MPAP	Multiple Parallel Approach Program
MVA	Minimum Vectoring Altitude
NAS	National Airspace System
NBO	Nuisance Breakout
NOZ	Normal Operating Zone
NTSB	National Transportation Safety Board
NTZ	No Transgression Zone
OM	Outer Marker
PF	Pilot Flying
PNF	Pilot Not Flying
PRM	Precision Runway Monitor
rms	Root Mean Square
SPO	Simulation Pilot Operator
SPW	Simulation Pilot Workstation
TCV	Test Criterion Violation
TERPS	Terminal Instrument Procedures
TG	Target Generation
TGF	Target Generation Facility
TNSE	Total Navigation System Error
TRACON	Terminal Radar Approach Control
TWG	Technical Work Group
WCB	Worst-Case Blunder

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Appendix A

Multiple Parallel Approach Program Summary

Multiple Parallel Approach Program Simulations

Phase	Dates	Purpose	Approach	Runway Spacing	Display	Simulated Radar	Other	TWG Recommendation
I	5/16-6/10/88	DFW	Quadruple	5000 ft 5800 ft 8800 ft	SANDERS/ DEDS	ASR-9 4.8s		Approved
II	9/25-10/5/89	DFW	Triple	5000 & 8800 ft	SANDERS/ DEDS	ASR-9 4.8s		Approved
III	11/29-2/9/90	DFW	Dual and Quadruple	5000 & 5800 ft 8800 ft	SANDERS/ DEDS	ASR-9 4.8s		Approved
IV.a	4/24-5/3/90	National Standards	Dual and Triple	4300 ft	ARTS III	ASR-9 4.8s		Dual in Progress Triple Not Approved
IV.b	9/17-9/28/90	National Standards	Triple	5000 ft	ARTS III	ASR-9 4.8s		Approved
V.a.1	5/15-5/24/91	National Standards	Dual and Triple	4300 ft	FMA	ASR-9 4.8s		Approved
V.a.2	9/24-10/4/91	National Standards	Triple	4000 ft	FMA	ASR-9 4.8s		Study Closed No Decision Rendered
V.a.2.2	7/27-8/14/92	National Standards	Dual and Triple	4000 ft	FMA	ASR-9 4.8s		Inconclusive
V.b.1 & V.b.2	3/18-4/5/91	National Standards	Dual and Triple	3000 ft	FMA	E-Scan 1.0s		Not Approved
V.b.3	9/16-9/23/91	National Standards	Dual	3000 ft	FMA	E-Scan 1.0s	1-Degree Localizer Offset	Study Closed See June '94
V.c	5/6/-5/14/91	National Standards	Triple	3400 ft	FMA	Mode S 2.4s		Study Closed No Decision Rendered
V.d	3/2-3/13/92	Human Factors Study	Triple	3400 ft	FMA	E-Scan 1.0s	1 Mr Radar Accuracy	N/A
n/a	9/8-9/25/92	Density Altitude Study	Triple and Quadruple	7600 ft 5280 ft 5348 ft	ARTS III	ASR-9 4.8s	Field Elevation 5431 ft	Study Closed No Decision Rendered
n/a	11/16-11/20/92 11/30-12/17/92	DIA	Triple	7600 ft 5280 ft	FDAs FMA	ASR-9 4.8s	Field Elevation 5431 ft	Approved
n/a	6/6-6/17/94	National Standards	Dual	3000 ft	FMA	E-Scan 1.0s	1-Degree Localizer Offset	Not Approved
n/a	7/11-7/22/94	National Standards	Dual	3000 ft	FMA	E-Scan 1.0s	2.5-Degree Localizer Offset	Not Approved
n/a	8/14-8/25/95	National Standards	Triple	4000 ft 5300 ft	FMA	E-Scan 1.0s		Evaluation In Progress
n/a	10/16-10/27/95	National Standards	Dual	3000 ft	FMA	E-Scan 1.0s	2.5-Degree Localizer Offset	Approved

Appendix B

Monte Carlo Simulation

B.1 Background

Real-time simulations of ATC operations have been used increasingly in the evaluation of new ATC procedures and airport configurations. In real-time simulations, controller and aircrew/aircraft performance can be measured individually and combined in the system performance measures. One benefit of conducting real-time simulations, with human operators, is that unexpected effects of the procedure on system performance can be identified. A limitation of real-time simulations is that only a relatively small number of conditions can be tested economically. Thus, the data collected is usually a very small subset of all the possible conditions.

Because of the small subset of data collected in real-time simulations, there is a relatively large margin of error in the observed measures. Confidence intervals are typically established to estimate the range of the simulation results. Since the sample sizes are relatively small, the confidence intervals are rather large. If the real-time simulation results are used in the evaluation of a tested procedure, it is possible that a decision to accept or reject a procedure could be in error.

One way to refine and/or expand the results of a real-time simulation is to conduct a computer simulation, commonly called a Monte Carlo simulation. This technique has been used successfully in the Multiple Parallel Approach Program (MPAP) and the PRM Demonstration Program to assess the probability of mid-air collisions during simultaneous parallel approach operations.

The Monte Carlo simulation uses the actual aircrew/aircraft and air traffic controller performance data collected in the real-time simulation and examines over 100,000 worst-case aircraft blunders. This large number of blunders results in a very small confidence interval for the estimated TCV rate.

Two different Monte Carlo models are being used in the MPAP, which are the Blunder Resolution Model (BRM) and the Airspace Simulation and Analysis for TERPS (ASAT) Model. The models were developed for analyses of controller, aircrew/aircraft, and system performance, and are described in the following sections.

B.2 Monte Carlo Simulation of Blunders During Simultaneous Approaches

The BRM was originally developed for the PRM Demonstration Program that ended in 1991. It was designed to measure the risk of a mid-air collision during simultaneous operations to dual parallel approaches. This was the first PRM risk assessment model to use data collected in the field or from experiments for each of the model components. Results from the BRM were used in the development of the current standards for simultaneous approaches to closely spaced parallel runways.

The ASAT model is a newer generation of Monte Carlo computer simulation. It was developed to perform complex multiple aircraft simulations in the study of obstacle clearance and airspace requirements for new standards and the re-evaluation of existing standards.

B.2.1 Monte Carlo Blunder Models

The BRM and the ASAT models are similar in their basic operation. The similarities are described below in Section B.2.1.1. Unique features of the BRM and the ASAT models are described in Sections B.2.1.2 and B.2.1.3, respectively.

B.2.1.1 Common Features of the BRM and ASAT

The purpose of each Monte Carlo simulation was to estimate the probability of a TCV as a result of one aircraft turning unexpectedly from one ILS approach toward another aircraft on an adjacent ILS approach. The blundering aircraft turned to a course 30 degrees from its approach course. The aircraft on the parallel approach, called the evader, continued its ILS approach until contacted by ATC.

Figures B-1 and B-2 show the components and flow of the simulations for the BRM and ASAT, respectively. The distance between aircraft at a given time was affected by several stochastic processes: initial position of the aircraft relative to the other aircraft, system delay, controller response time, communication delay, and endangered pilot/aircraft response. The values for each component were declared at the beginning of each scenario. Simulation components, such as runway configuration and surveillance performance, remained fixed for all trials.

The timing of the NTZ entry alert was determined based upon the configuration of the blundering aircraft at the start of the blunder. The timing was affected by the position of the aircraft relative to the NTZ, initial heading, speed, and random surveillance errors. The aircraft positions were then analyzed using the PRM alert logic. An alert was generated when an aircraft, the blundering aircraft in this case, was either inside the NTZ or projected to be inside the NTZ within 10 seconds.

During each trial, the blundering aircraft descended along the approach path until it reached the blunder start position. The approach course had a 3-degree glide slope and aircraft decreased speed in accordance with data collected in the real-time simulation. The blundering aircraft then turned toward the adjacent approach using a standard rate turn of 3 degrees per second. The aircraft continued turning until the blunder heading was reached. The blundering aircraft then continued at the final blunder heading until the end of the trial. The blunders were executed between 1.0 nm and 12.0 nm from the runway threshold.

System delay, communication delay, and controller response time were based on parameter assignments. System delay is defined herein as the interval between the start of aircraft interrogation to the time the detected or tracked target appears on the controller display. System delay was a constant based upon the PRM system specification. It was set to 0.46 second for the ASAT and 0.50 second for the BRM. The communication delay was a random occurrence and as such was incorporated into the pilot response times generated in the real-time simulation.

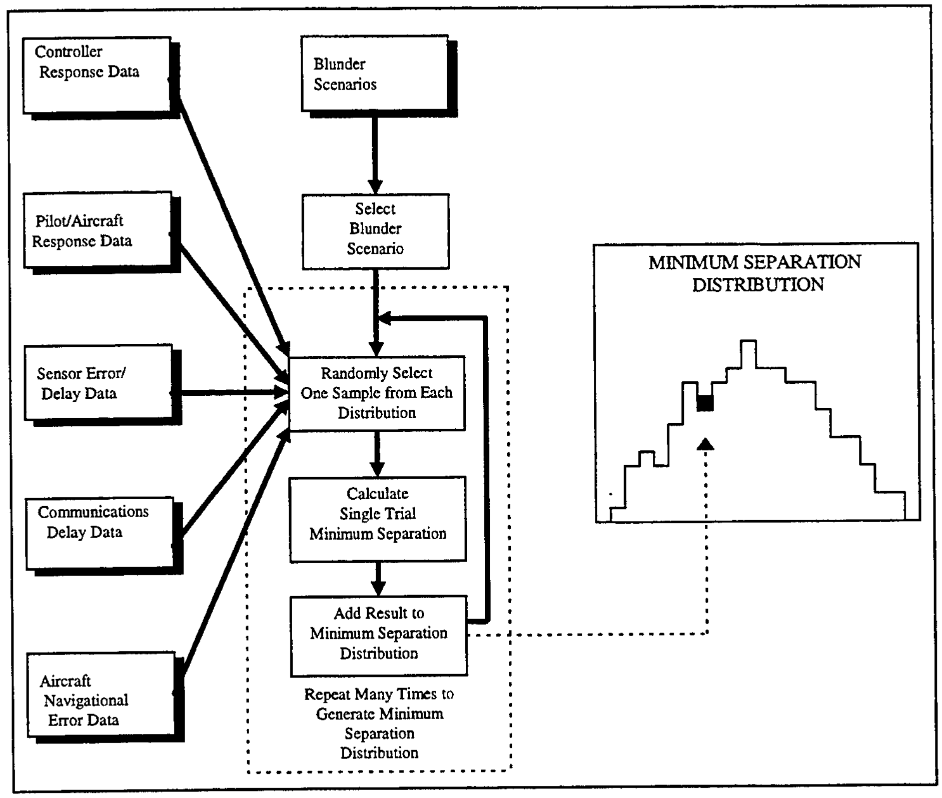


Figure B-1. PRM Blunder Resolution Model.

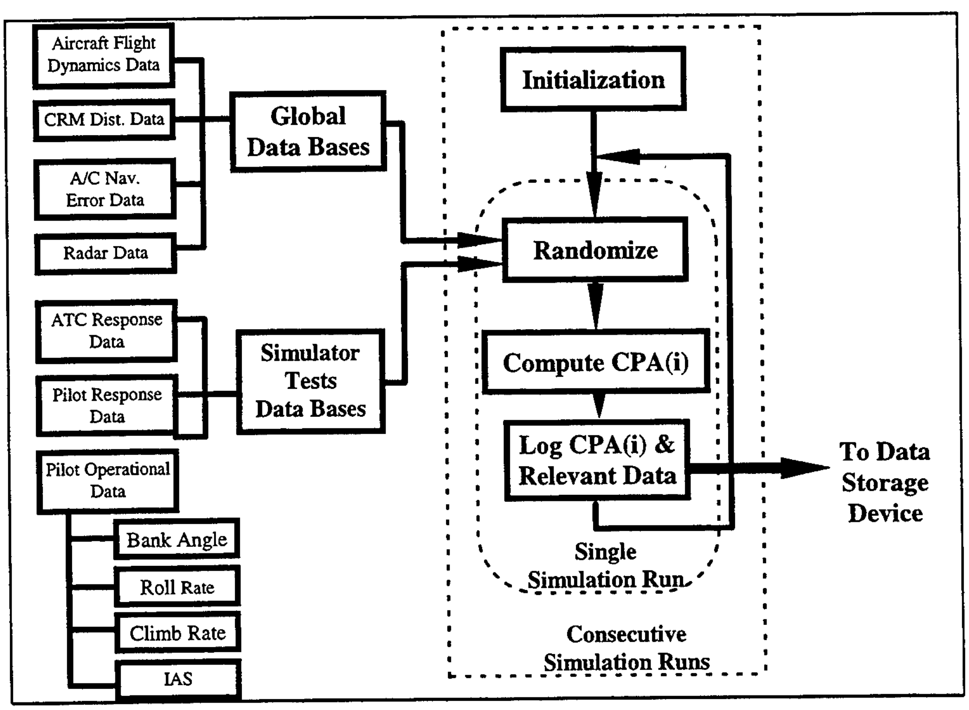


Figure B-2. Airspace Simulation and Analysis for TERPS (ASAT) Model.

Controller response times were randomly selected from data collected in the real-time simulation. Each response time was measured as elapsed time from the start of the NTZ alert until the controller of the evading aircraft began a message to the evading aircraft.

The slant distance between blundering and endangered aircraft centers was updated at least once every second. The trial was stopped when the closest point of approach (CPA) occurred. The miss distance was added to the set of miss distances. If a TCV occurred, that information was added to a file containing TCV data. The computer simulations then began the process again by selecting the positions and response variables for the next trial.

B.2.1.2 Unique Features of the BRM

The BRM used computer-generated tracks for the blundering aircraft, which were based on a spatial flight trajectory model, and actual tracks recorded by cockpit simulators during the real-time simulation for evading aircraft tracks. The evading aircraft track was randomly selected from a set of track files, which were grouped according to position along the approach course. This ensured that the performance and configuration of the evading aircraft were appropriate for the location of the event. The range groupings were as small as possible to ensure correct speeds and maneuvers, while providing at least 50 evader responses per range. For each trial, the evader track was shifted slightly along the approach so it would be aligned with the starting position randomly selected at the start of the trial. The track was also aligned in time so that the start of the ATC breakout instruction in the BRM simulation matched the point where it occurred during the recording of the track in the real-time simulation.

The benefit of this method was that it accurately portrayed the observed pilot/aircraft response characteristics. There were no assumptions about independence of actions, the possible combination of actions, or the correctness of the responses. The actual sequencing of pilot actions and the actual inputs to the aircraft were represented. The limitation was that only a small subset of responses were represented. Since a single outlier response could have been over-represented because of sample size, the TCV results tended to be conservative.

In the BRM, the range of the evading aircraft was randomly chosen to be within 1.5 nm of the blundering aircraft. This represented the independent sequencing of aircraft on adjacent approaches that occurs during simultaneous parallel approaches. A factor of 1/17 was then applied to estimate the percentage of at-risk blunders. This was the same technique that was used to convert the 0.4 percent general-case TCV rate criterion from the PRM Demonstration Program to the 6.8 percent criterion for this study. This technique resulted in a conservative estimate of the TCV rate because it included TCVs that might not have been associated with at-risk configurations. Rather, these TCVs were the result of human actions. The benefit was that these non at-risk TCVs were represented in the results and could be identified and analyzed for contributing factors.

B.2.1.3 Unique Features of the ASAT Model

The ASAT model combined a high fidelity flight dynamics and FMS/autopilot model with atmospheric models for wind, temperature, and pressure. The flight dynamics and FMS/autopilot models were developed from flight data supplied by aircraft manufacturers. The models were

comparable in fidelity to the flight dynamics models used in certified motion-based flight simulators. The types of aircraft modeled using the ASAT included a B747, B727, MD90, ATR42, and an ATR72. The atmospheric model was comparable to those used in certified motion-based flight simulators. The ASAT also modeled radar tracking systems and human performance.

Evader pilot and aircraft response characteristics were extracted from the real-time simulation data to produce evader flight tracks in the ASAT model. The empirical data were grouped according to similarities of the data. For example, the maximum bank angles for the B747 and MD90 were found to be similar, so their maximum bank angle data were grouped together to form one distribution. The maximum bank angles for the B727s at AVIA and Oklahoma City formed separate distributions and were represented separately in the conduct of the ASAT model. Probability density distributions of aircraft performance data were developed for each aircraft group. These data included indicated airspeeds, roll rates, maximum bank angles, and rates of climb. Since the ATR42 and ATR72 were not simulated during the real-time simulation, data for those aircraft were not available. Probability curves for the B747 were used to provide the evasion maneuvers of the ATR42 and ATR72. It was felt that these distributions would provide conservative evasion maneuvers for the two ATR aircraft.

The benefit to fitting continuous curves to the pilot and aircraft performance characteristics was that a complete spectrum of responses could be represented. This reduced the effect of a single combination of performance characteristics on the TCV rate. In the implementation of ASAT for this simulation, the combinations of roll, pitch, and engine performance were assumed to be independent.

In the ASAT, the aircraft were positioned so that the evading aircraft was at risk. This was accomplished by first selecting a position for the evading aircraft. The position of the evading aircraft was determined laterally and vertically by random sampling from the probability distributions found in the ICAO Collision Risk Model (CRM). The longitudinal position of the evading aircraft was set at an integral number of nautical miles from the threshold ranging from 2 to 12 nm. The position of the blundering aircraft also was determined laterally and vertically by random sampling from the probability distributions found in the ICAO CRM. The blundering aircraft was positioned longitudinally by first positioning it somewhat closer to the threshold than the evading aircraft. Then the model was activated so that the blundering aircraft performed the blunder maneuver, but the evading aircraft flew on course without an evasion maneuver.

As the blunderer passed the lateral position of the evader, the simulation was stopped and the miss distance was used to adjust the starting position of the blundering aircraft so that the evading aircraft would be at risk. The model was activated again and the evading aircraft performed an evasion maneuver. The roll rate, climb rate, maximum bank angle, and heading change of the evading aircraft were randomly selected from distributions derived from the real-time simulation. These were categorized based upon the aircraft positions at the blunder start. This method can create an unlimited combination of aircraft tracks and aircraft pairings.

This method resulted in a very accurate determination of TCVs associated with at-risk blunder configurations. It was also comparable to the method used in the real-time simulation.

B.2.2 Configuration of the Monte Carlo Models

For this study, the Monte Carlo simulations were configured to match, as closely as possible, the real-time simulation:

a. Same runway and approach configuration

b. Similar TNSE errors

c. Similar aircraft speed distributions

d. Similar distributions of blunder starting points

e. Same blunder configuration (30-degrees, nonresponding)

f. Similar distributions of controller and endangered aircraft responses

The controller response times relative to the auditory NTZ entry alert were extracted from the real-time simulation. The controller responses were analyzed for any factors that could have influenced the type of breakout instruction or delay. Analyses indicated that the relative position between the blundering and evading aircraft did not affect the controller response time. Analyses also showed that the distance of the blunder from the threshold did not affect the controller response time. A probability density curve was fit to the data. This filled in the gap between 3 s and 10 s, for which there were no real-time ATC response data, resulting in a continuous distribution of responses for the computer simulations.

It was felt that some of the observed response times by the air traffic controllers were extremely short and that these short responses were induced by the simulation environment. Air traffic controllers would probably not react before the NTZ alert in the operational environment. Therefore, the ASAT model restricted controller reaction times to greater than or equal to 0.2 seconds in the analysis of the approach operation.

Since standard pilot procedures limit the aircraft to 30 degrees of bank, the maximum bank angle in the ASAT simulation was limited to values less than or equal to 30 degrees. Similarly, the maximum roll rate was limited to 8 degrees per second, and the maximum rate of climb was limited to 4000 feet per minute. Limiting the distributions in this way resulted in slower evasive maneuvers and thus a more conservative simulation.

B.2.3 Monte Carlo Output

The output of each Monte Carlo simulation was a distribution of CPAs for at least 100,000 trials. To estimate the TCV rate, the number of CPAs less than 500 ft was divided by the total number of at-risk blunders. The TCV rate results were then used in the analyses of the operational safety of the procedure.

Estimates of the probability of a blunder occurring during actual simultaneous approach operations can be compared with the simulation results to determine the safety of the proposed operation. The TCV rate is combined with factors that estimate the probability of aircraft alignment (1/17), the probability the blundering aircraft does not respond (1/100), the probability of a blunder (1/2000), and the probability that a blunder will be 30 degrees (1/100).

Additionally, the Monte Carlo simulations can be used to conduct sensitivity analyses. The sensitivity analyses can be used to examine the procedure if limits are set on system performance. An example would include slowing all controller responses by 1 second.

B.2.4 Conclusion

The Monte Carlo simulations provide a means of enhancing the findings of a real-time simulation. They produce unlimited combinations of data from the limited set of data collected in the real-time simulation. They provide the researcher with a cost effective method of refining the analyses and provide more accurate results to compare with test criteria. By refining the results, the FAA is less likely to incorrectly accept or reject a simulated air traffic control procedure.

Appendix C

Risk Analysis

C.1 Overview

The TWG has agreed to an analysis that relates the collision rate observed in the simulation to the test criterion of less than 1 fatal accident per 25 million approaches (4 x 10^{-8}). Analysis has shown that if the collision rate, given that an at-risk Worst-Case Blunder (WCB) has occurred, is less than 6.8 percent, then the overall risk of a collision accident resulting from the simultaneous instrument approach procedure will be less than the test criterion.

MPAP simulations measure the Test Criterion Violation (TCV) rate, (i.e., the proportion of at-risk WCBs resulting in aircraft proximity of less than 500 ft). If one assumes that a TCV represents a collision, then the TCV rate observed in the simulation is an estimate of the risk of a collision on a simultaneous instrument approach, given that a WCB occurs and the aircraft are at risk.

The real-time simulation TCV rate is an imprecise estimate of the collision risk resulting from a WCB since it represents only a small sample of blunders (usually 200 to 300 at-risk WCBs per simulation). With a small sample, it is possible for the measured TCV rate to exceed 6.8 percent, while the actual collision risk is less than 6.8 percent, and vice versa. This is because the sampling error is large, resulting in a large confidence interval for the true collision rate.

Therefore, two Monte Carlo simulations are used to increase the sample size and decrease the error in the measured TCV rate. The Monte Carlo simulations use human and aircraft response data from the real-time simulation to generate altogether over 500,000 at-risk WCBs. The Monte Carlo sample sizes produce refined estimates of the collision risk. After validating the consistency of the Monte Carlo results with the real-time results, the Monte Carlo results are used to determine if the procedure has an acceptably low level of risk.

C.2 Risk Analysis

Several events must occur simultaneously for a collision to occur during simultaneous instrument approaches. Clearly, a blunder must occur, or there would be no significant deviation from course. Previous testing has shown that blunders other than WCBs are of negligible risk, so the blunder must be a WCB. Also, the blundering aircraft must have a critical alignment with an aircraft on an adjacent course (i.e., it must be at risk). If all of the above events develop, a TCV will occur if the controller and pilots cannot react in sufficient time to separate the blundering and the evading aircraft. In addition, one collision will involve two aircraft and will probably produce two accidents, as defined by the National Transportation Safety Board (NTSB).

Assuming that a TCV will result in a collision, the probability of a collision accident can be expressed in mathematical terms by:

(1) P(Accident) = P(TCV and At-risk and WCB and Blunder) x 2

or

(2) P(Accident) = P(TCV|At-risk and WCB and Blunder) x

P(At-risk|WCB and Blunder) x

P(WCB|Blunder) x

P(Blunder) x 2

Where:

P(TCV and At-risk and WCB and Blunder) is the probability of all relevant events occurring simultaneously (i.e., an at-risk WCB that results in a TCV).

P(TCV|At-risk and WCB and Blunder) is the probability that a TCV occurs given that an at-risk WCB has occurred. This quantity is estimated by the simulation of at-risk WCBs in the real-time and Monte Carlo simulations (i.e., the TCV rate in the simulation).

P(At-risk|WCB and Blunder) is the probability that a WCB has critical alignment with an aircraft on an adjacent approach. Analysis conducted in preparation for this simulation indicates that a value of 1/17 is a good approximation of this quantity, given 3 nm in-trail spacing.

P(WCB|Blunder) is the probability that a blunder is a WCB. This probability is unknown, but is estimated to be approximately 1/100 (PRM Demonstration Report, 1991).

P(Blunder) is the probability that a blunder occurs during a simultaneous instrument approach. This rate is also unknown, but is estimated to be no more than 1/2000 approaches. This is a conservative value derived from the risk analysis conducted during the PRM demonstration program. Until a blunder rate estimate can be derived from field data of actual blunder occurrences or other evidence suggests using a different value, the TWG has agreed to use 1/2000.

The factor of 2 represents two accidents per collision.

C.3 Target Level Of Safety

The total number of air carrier accidents, as well as the number of fatal accidents on final approach, has been extracted from NTSB data for the time period, 1983-1989. This number, together with the total number of ILS approaches flown during this time period, leads to an estimated fatal accident rate during ILS operations performed during IMC of 4×10^{-7} fatal accidents (ACC) per approach (APP). There are a number of causes of accidents during final approach, such as structural failure, engine failure, or midair collision. An initial estimate is that there are nine possible causes of accidents on final approach. A tenth possible accident cause, a collision with an aircraft on an adjacent approach, is created with the implementation of simultaneous parallel approaches.

For simplicity of model development, it is assumed that the risks of the ten potential accident causes are equal. Thus the contribution of any one of the accident causes would be one-tenth of the total accident rate. Based on this, the target safety level for midair collisions on simultaneous parallel approaches is 4×10^{-8}, or:

$$\frac{1 \text{ ACC}}{25 \text{ mill APP}}$$

C.4 Maximum Allowable Test Criterion Violation Rate

Since the only undefined variable in equation (2), used to compute the maximum acceptable accident rate, is the TCV rate, it is possible to determine the maximum allowable TCV rate which would meet the target level of safety. Knowledge of this number would allow the TWG to quickly decide if the simulated operation would meet the target level of safety. The maximum allowable TCV rate may be found from following analysis.

Given the target level of safety, P(Accident) = 4×10^{-8}, then the equation (2) becomes:

$$P(\text{TCV}|\text{At-risk and WCB and Blunder}) \times P(\text{At-risk}|\text{WCB and Blunder}) \times P(\text{WCB}|\text{Blunder}) \times P(\text{Blunder}) \times 2 = 4 \times 10^{-8}$$

or,

(3)

$$P(\text{TCV}|\text{At-risk and WCB and Blunder}) = \frac{4 \times 10^{-8}}{1} \times \frac{1}{P(\text{At-risk/WCB and Blunder})} \times \frac{1}{P\ (\text{WCB/Blunder})} \times \frac{1}{P(\text{Blunder})} \times \frac{1}{2}$$

Substituting values from (2) into (3):

(4)

$$P(\text{TCV}|\text{At-risk and WCB and Blunder}) = \frac{4 \times 10^{-8}}{1} \times \frac{17}{1} \times \frac{100}{1} \times \frac{2000}{1} \times \frac{1}{2} = 6.8\%$$

Thus, if the simulation results support the assertion that the probability of a TCV, given that an at-risk WCB occurs (P(TCV|At-risk and WCB and Blunder)), is less than 6.8 percent, then the simultaneous approach procedure simulated should have an acceptable accident rate.

The TCV rate derived directly from the real-time simulation is subject to variation due to the small sample of at-risk, worst-case blunders obtained from the simulation. To compensate for this variation, a 99-percent confidence interval of the TCV rate is computed from the observed TCV rate and sample size. If the largest value of the confidence interval is less than 6.8 percent, then it is very likely (the probability is 0.995) that the actual TCV rate is less than 6.8 percent and the simulated procedure may be considered to have an acceptable risk of collision. However, given the small sample size, it is possible for the confidence interval to extend above 6.8% even though the true TCV rate is less than 6.8%.

Two Monte Carlo simulations are used, based on data derived from the real-time simulation, to effectively increase the sample size of worst-case blunders to over 500,000 in all and provide two more estimates of the TCV rate. Since the sample sizes are very large, the 99-percent confidence intervals obtained from the Monte Carlo simulations will be much smaller than the confidence interval obtained from the real-time simulation. If the TCV rates observed in the real-time simulation and the Monte Carlo simulations are statistically consistent and if the largest values of the Monte Carlo simulation confidence intervals are less than 6.8 percent, then the simulated procedure is considered to have an acceptable risk of collision.

C.6 Summary Of The Risk Evaluation Process

The process used by the TWG to determine whether the simulated operation meets the target level of safety may be summarized as follows:

- Conduct the real-time simulation and determine the number of at-risk WCBs and the number of TCVs.
- Validate the observed TCVs.
- Compute the TCV rate by dividing the number of valid TCVs by the number of at-risk WCBs in the simulation (denoted TCV_{rt}).
- Calculate a 99-percent confidence interval for TCV_{rt} using standard statistical techniques (confidence interval for the proportion parameter of a binomial distribution).
- Use controller, pilot, and aircraft response data to conduct two Monte Carlo simulations of at least 100,000 at-risk WCBs, as discussed in Appendix B. Record the number of TCVs observed.
- Calculate the TCV rates for the Monte Carlo simulations by dividing the number of TCVs observed in the Monte Carlos by the number of at-risk WCBs (denoted TCV_{mc}).
- Calculate 99-percent confidence intervals for TCV_{mc} using standard statistical techniques (confidence interval for the proportion parameter of a binomial distribution).

- Compare TCV_{rt} and TCV_{mc} using standard statistical techniques (test for difference of proportions) to ensure that the Monte Carlo and real-time simulations produce consistent results.

- If the simulations have not produced consistent results (i.e., the statistical test shows a difference of proportions with 99 percent confidence between the Monte Carlo and real-time simulations), then additional analyses must be conducted to reconcile the Monte Carlo and real-time test results.

- If the test results are consistent and the upper limits of the 99-percent confidence intervals for TCV_{mc} are less than 6.8 percent, then the tested operation has an acceptable risk of collision.

Appendix D

Controller Briefing

CONTROLLER BRIEFING

FOR THE

MULTIPLE PARALLEL APPROACH PROGRAM

SIMULATION

October 16 - 27, 1995

FAA Technical Center

Atlantic City International Airport, NJ

OVERVIEW

THE MULTIPLE PARALLEL APPROACH PROGRAM (MPAP) TECHNICAL WORK GROUP (TWG)

- Investigates the use of triple, quadruple, and closely-spaced dual parallel runway configurations through the conduction of real-time simulations.
- Comprised of Federal Aviation Administration representatives from the Secondary Surveillance Product Lead, Office of System Capacity and Requirements, Flight Standards Service, Air Traffic Rules and Procedures Service, Office of Air Traffic System Management, Air Traffic Plans and Requirements Service, the Southwest Region, and the FAA Technical Center.

PROGRAM GOALS

- To increase airport capacity by conducting multiple simultaneous parallel ILS approaches, including:
  - triple and quadruple parallel runways.
  - closely-spaced dual parallel runways.
- To examine operational issues and make recommendations for the establishment of national standards for multiple simultaneous parallel ILS approaches.

DEFINITIONS

(As defined for this simulation)

Blunder - An unexpected turn by an aircraft already established on the localizer toward another aircraft on an adjacent approach.

Breakout - A technique used to direct aircraft out of the approach stream. In the context of close parallel operations, a breakout is used to direct an aircraft away from a deviating aircraft while simultaneous operations are being conducted.

CPA - [Closest Point of Approach] The smallest slant range distance between two aircraft involved in a conflict. The distance is measured from the center of each aircraft.

NBO - [Nuisance Breakout] An event that occurs when an aircraft is broken out of its final approach for reasons other than a blunder, loss of longitudinal separation, or lost beacon signal (i.e., aircraft goes into coast).

NOZ - [Normal Operating Zone] The operating zone within which aircraft flight remains during normal independent simultaneous parallel ILS approaches.

NTZ - [No Transgression Zone] A 2000-ft wide zone located an equal distance between parallel runway final approach courses, in which flight is not allowed.

TNSE - [Total Navigation System Error] The difference between the actual flight path of the aircraft and its intended flight path. It is caused by flight technical error, avionics error, ILS signal error, and weather.

SIMULATION PURPOSE

- To evaluate the feasibility of and make recommendations on the air traffic control systems ability to support:

  Dual simultaneous ILS approaches to two parallel runways spaced 3000 feet apart with one localizer offset to the left by 2.5 degrees using the Precision Runway Monitor (PRM) system.

- To evaluate procedures and operational issues, NOT individual controller performance.

PRM VIDEO

DISCREPANCIES FROM VIDEO

VIDEO:	SIMULATION:
• Parallel Runway Monitor	Precision Runway Monitor
• Active expansion	4:1 expansion ratio
• Yellow alert zone	No Transgression Zone only
• Adjustable deviation lines	200-ft interval deviation lines
• 3-line data block	2-line data block w/ time share
• Adjustable predictor line	10-second predictor lines
• Adjustable target trails	5-second target trails
• Caution, Call Sign	Call Sign only

PRM SYSTEM

- The PRM system consists of:
  - Final Monitor Aid display
  - E-Scan radar system
  - 1.0-second radar update rate
- The FMA display is a high resolution 20 x 20 inch color monitor which displays the following close parallel approach information at an expansion ratio of 4:1:
  - No Transgression Zone (NTZ)
    - Outlined in red
    - 2,000 feet wide
    - Equidistant between ILS approach courses
    - Extends 1/2 mile beyond departure ends of the runways
  - Deviation lines
    - Solid white lines
    - 200-ft intervals from ILS localizer course
  - Extended runway centerlines
    - Dashed white lines
    - Each dash and each space equal to 1 nm

  The display intensity may be adjusted as desired. All other variables of the display must remain constant.
- An aircraft predictor line is a straight line projecting from the aircraft target. The predictor line shows where the aircraft will be in 10 seconds, if the aircraft continues at its current velocity and heading.
- When an aircraft is within 10 seconds of entering the NTZ, the aircraft target and data block changes from green to yellow. Also at this time, an auditory

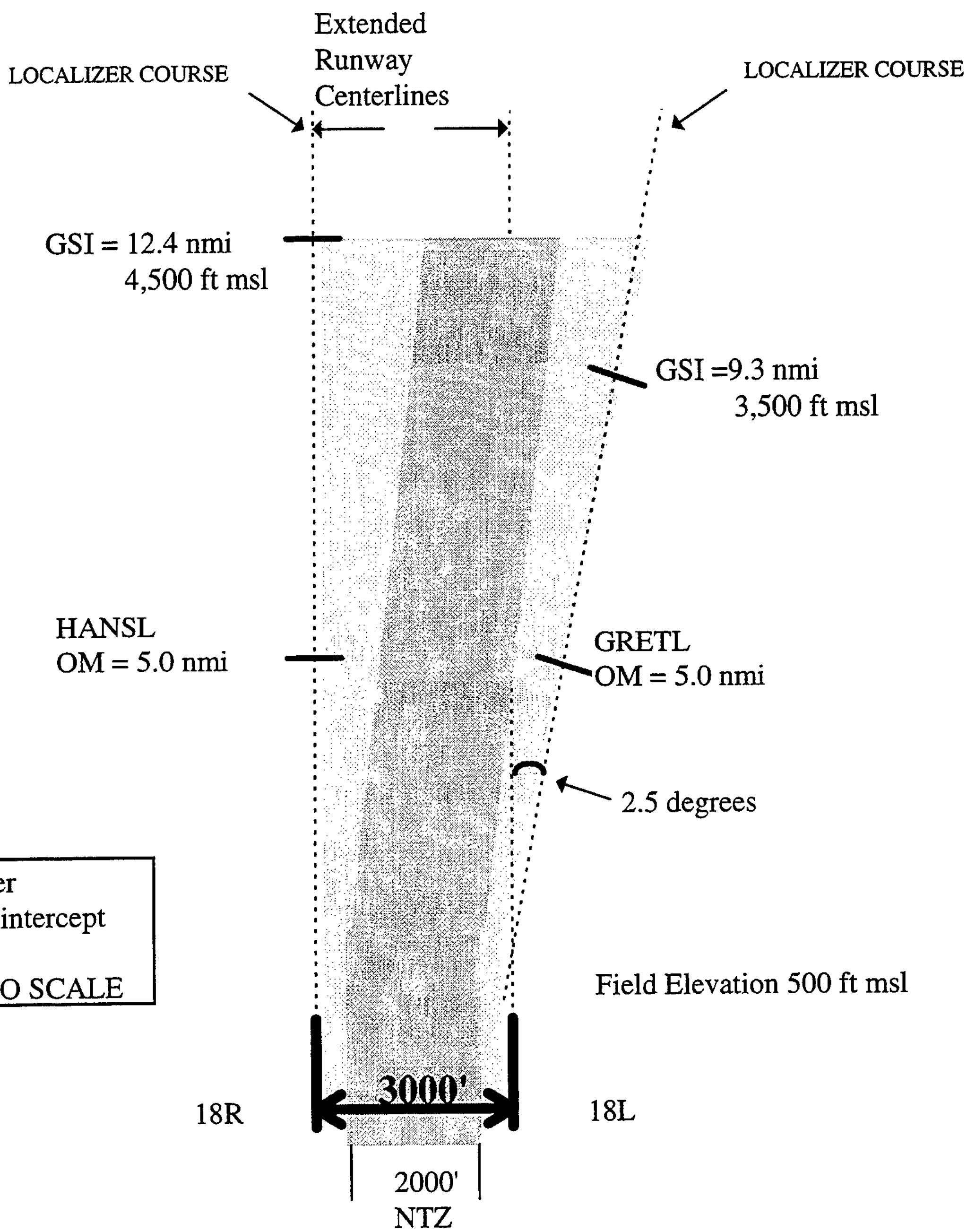
alert sounds, giving the call sign of the deviating aircraft. When an aircraft enters the NTZ, the aircraft target and data block changes from yellow to red.

AIRPORT APPROACH AREA CONFIGURATION

The simulated generic airport, referred to as Charlie Airport, is configured as follows:

- Two parallel runways
  - Spaced 3000 feet apart
  - 10,000 feet in length
  - Even thresholds
- 18L localizer offset to the left by 2.5 degrees
- Glide slopes of 3 degrees
- Outer markers located 5 nm from the runway thresholds
- Field elevation of 500 feet MSL
- Minimum vectoring altitude (MVA) of 1800 feet MSL

AIRPORT CONFIGURATION



OM = Outer marker
GSI = Glide slope intercept

NOT DRAWN TO SCALE

APPROACH PLATE 18R

TWGESSEN CHARTS 16 OCT 95 11-1A

CHARLIE, USA

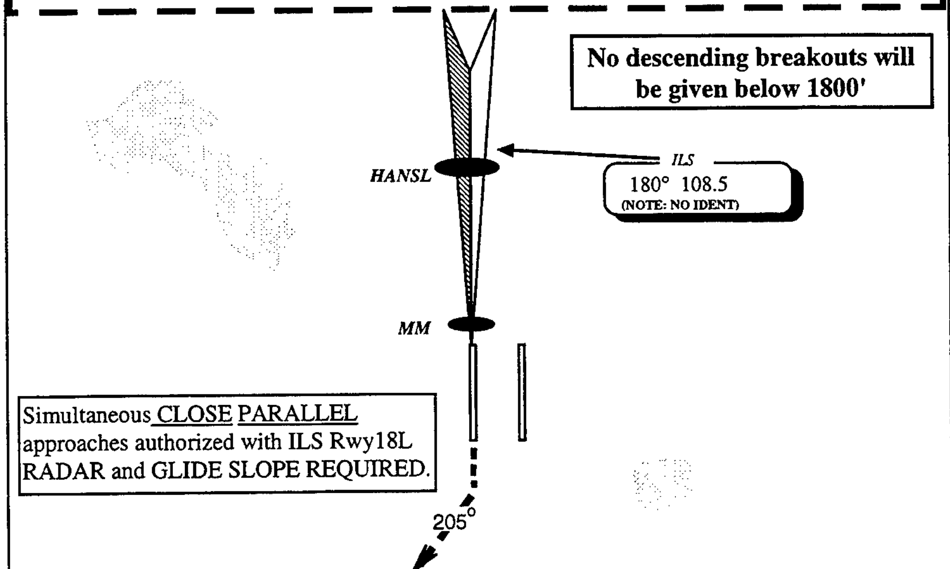
CHARLIE INTL
ILS Rwy 18R
(CLOSE PARALLEL)
LOC 108.5
(NOTE: NO IDENT)

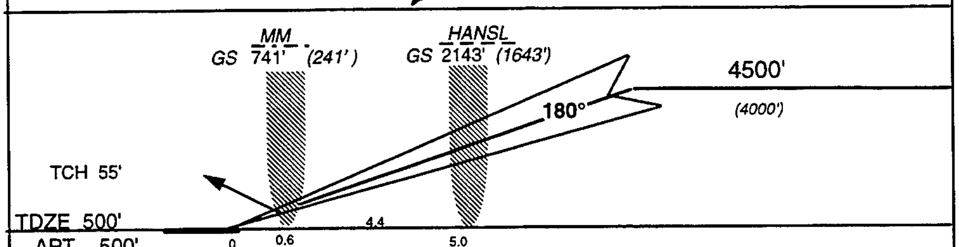
ATIS Arrival	**XXX.X**	
CHARLIE Approach (R)	**XXX.X**	
CHARLIE Tower Rwys	**18R-36L**	**127.2**
	18L-36R	126.8
Ground **121.9**		

2000' *MSA*

HANSL OM *Apt. Elev* **500'**

11-0 MUST BE READ PRIOR TO FLYING THIS CLOSE PARALLEL APPROACH





APT. 500'

MISSED APPROACH: Climb to 1000' then climbing right turn to 5000' via heading 205° and expect radar vectors.

	STRAIGHT - IN - LANDING RWY 18R ILS DA(H) **700'** (200')				CIRCLE - TO - LAND MDA
	FULL	TDZ or CL out	ALS out	LOC (GS Out)	
A B C D	RVR **18** or 1/2	RVR **24** or 1/2	RVR **40** OR 3/4	**Not Authorized**	**Not Authorized**

Gnd speed - Kts	70	90	100	120	140	160
GS 3.00°	378	486	540	648	756	864

APPROACH PLATE 18L

TWGESSEN CHARTS 16 OCT 95 11-2A

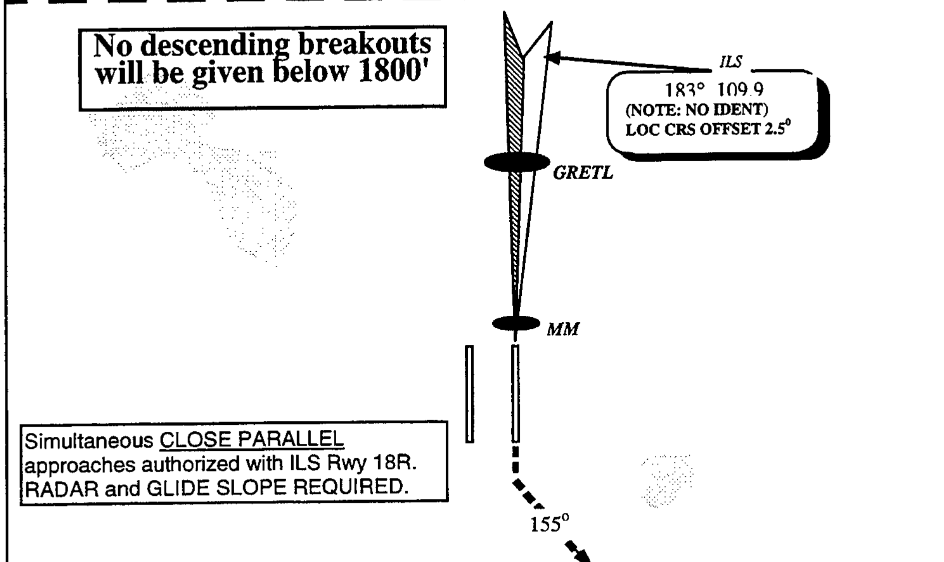
CHARLIE, USA
CHARLIE INTL
ILS Rwy 18L
(CLOSE PARALLEL)
LOC 109.9
(NOTE: NO IDENT)

ATIS Arrival	**XXX.X**	
CHARLIE Approach (R)	**XXX.X**	
CHARLIE Tower Rwys	**18L-36R**	**126.8**
	18R-36L	127.2
Ground	**121.9**	

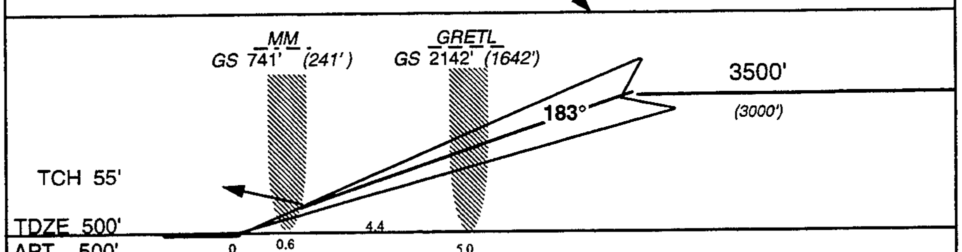
2000' *MSA* *GRETL OM* *Apt. Elev* **500'**

11-0 MUST BE READ PRIOR TO FLYING THIS CLOSE PARALLEL APPROACH

No descending breakouts will be given below 1800'



Simultaneous CLOSE PARALLEL approaches authorized with ILS Rwy 18R. RADAR and GLIDE SLOPE REQUIRED.



MISSED APPROACH: Climb to 1000' then climbing left turn to 4000' via heading 155° and expect radar vectors.

	STRAIGHT - IN - LANDING RWY 18L				CIRCLE - TO - LAND
	DA(H) **750'** (250')			LOC (GS Out)	MDA
	FULL	TDZ or CL out	ALS out		
A B C D	RVR **18** or 1/2	RVR **24** or 1/2	RVR **40** OR 3/4	**Not Authorized**	**Not Authorized**

Gnd speed - Kts	70	90	100	120	140	160
GS 3.00°	378	486	540	648	756	864

CONTROLLER RESPONSIBILITY

- You are the final monitor controller. Your responsibility is to maintain longitudinal and lateral separation from aircraft on the adjacent localizer between the simultaneous approach fixes to 1/2 mile beyond the departure ends of the runways.

- The aircraft will be established on the localizer and displayed on the FMA. You must ensure that each aircraft has established contact with the tower prior to the first simultaneous ILS approach fix.

- <u>OVERVIEW OF RESPONSIBILITY</u>:

All turn-ons and final approaches are monitored by radar. Since the primary responsibility for navigation rests with the pilot, instructions from the controller are limited to those necessary to ensure separation between aircraft. Information and instructions are issued, as necessary, to contain the aircraft flight path within the Normal Operating Zone (NOZ). Aircraft which are observed to enter the No Transgression Zone (NTZ) are instructed to alter course left or right, as appropriate, to return to the desired course. Unless altitude separation is assured between aircraft, immediate action must be taken by the controller monitoring the adjacent parallel approach course to require the aircraft in potential conflict to alter its flight path to avoid the deviating aircraft.

(FAA Order 7210.3K, p 12-45f)

- <u>OVERRIDE CAPABILITIES</u>:

Separate monitor controllers, each with transmit/receive and override capability on the local control frequency, shall ensure aircraft do not penetrate the depicted NTZ.

(FAA Order 7110.65J, p 5-9-7b.6 note 1)

- <u>NO TRANSGRESSION ZONE (NTZ)</u>:

The primary responsibility for navigation on the final approach course rests with the pilot. Control instructions and information are issued only to ensure that aircraft do not penetrate the NTZ.

(FAA Order 7110.65J, p 5-9-7b.5)

Controller Responsibility (Continued)

- FINAL MONITOR WORK PAD:

Controllers shall use a pad to keep track of aircraft as follows:

1. Determine approach sequence from data block and write down aircraft call sign.
2. Place a check mark beside the call sign when the aircraft checks on tower frequency.
3. Draw a line through the aircraft call sign when radar monitoring is terminated for that aircraft.

- CONTROL INSTRUCTIONS:

The aircraft is considered the center of the digitized target for that aircraft for the purposes of ensuring an aircraft does not penetrate the NTZ.

1. Instruct the aircraft to return immediately to the correct final approach course when the aircraft is observed to overshoot the turn-on or continue on a track which will penetrate the NTZ.

Phraseology:

"YOU HAVE CROSSED THE FINAL APPROACH COURSE. TURN (left/right) IMMEDIATELY AND RETURN TO LOCALIZER/AZIMUTH COURSE."

or

"TURN (left/right) AND RETURN TO THE LOCALIZER/AZIMUTH COURSE."

2. Instruct aircraft:

    a. That have entered the NTZ or are established on a track that will enter the NTZ to alter course.

    b. On the adjacent final approach course to avoid a deviating aircraft.

Controller Responsibility (Continued)

Phraseology:

"TRAFFIC ALERT, (A/C call sign) TURN (left/right) IMMEDIATELY HEADING (degrees), CLIMB AND MAINTAIN (altitude)."

(Proposed change to FAA Order 7110.65)

3. Standard breakout instructions for the simulation are as follows:

   a. Runway 18R: TURN RIGHT IMMEDIATELY HEADING TWO SEVEN ZERO, CLIMB AND MAINTAIN FIVE THOUSAND.

   b. Runway 18L: TURN LEFT IMMEDIATELY HEADING ZERO NINE ZERO, CLIMB AND MAINTAIN FOUR THOUSAND.

4. As soon as feasible exchange traffic and wake turbulence information.

- <u>SPEED ADJUSTMENT</u>:

"Do not assign speed adjustment to aircraft inside the final approach fix on final or a point 5 miles from the runway, whichever is closer to the runway."

(FAA Order 7110.65J, p 5-7-1b.4)

<u>PILOT VIDEO</u>

<u>COMMUNICATION</u>

- NORDO Aircraft
- Blocked Communications

CONTROLLER PARTICIPATION

- A total of 12 monitor controllers (6 each week) will participate throughout the simulation.
- Three two-hour runs will be conducted each day.
- Controllers will rotate midway through each run.
- Controllers will not be scheduled to participate more than one hour per two-hour run, and will not participate more than three hours a day.
- Controller assignments will be equally divided with respect to runways and traffic scenarios.
- Controllers will randomly choose letter identification codes to ensure anonymity. The codes should be used for marking questionnaires and referred to when reading the controller schedule.
- Controllers will be required to complete a short questionnaire at the end of each day and at the end of the simulation.

CONTROLLER SCHEDULE
October 16-27, 1995

DATE	RUN	18R	18L
10/16 Monday	1a (Practice)	A	B
	1b (Practice)	C	D
	2a (Practice)	E	F
	2b (Practice)	A	C
	3a (Practice)	B	E
	3b (Practice)	D	F
10/17 Tuesday	4a	E	A
	4b	D	B
	5a	C	F
	5b	A	D
	6a	F	C
	6b	B	E
10/18 Wednesday	7a	F	B
	7b	A	E
	8a	D	C
	8b	B	A
	9a	C	D
	9b	E	F

CONTROLLER SCHEDULE
October 16-27, 1995

DATE	RUN	18R	18L
10/19	10a	F	A
Thursday	10b	B	C
	11a	D	E
	11b	B	A
	12a	F	E
	12b	C	D
10/20	13a	A	B
Friday	13b	C	D
	14a	D	F
	14b	A	C
	15a	B	E
	15b	D	F

CONTROLLER SCHEDULE

October 16-27, 1995

DATE	RUN	18R	18L
10/23	16a (Practice)	G	H
Monday	16b (Practice)	I	J
	17a (Practice)	K	L
	17b (Practice)	G	I
	18a (Practice)	H	K
	18b (Practice)	J	L
10/24	19a	K	G
Tuesday	19b	J	H
	20a	I	L
	20b	G	J
	21a	L	I
	21b	H	K
10/25	22a	L	H
Wednesday	22b	G	K
	23a	J	I
	23b	H	G
	24a	I	J
	24b	K	L

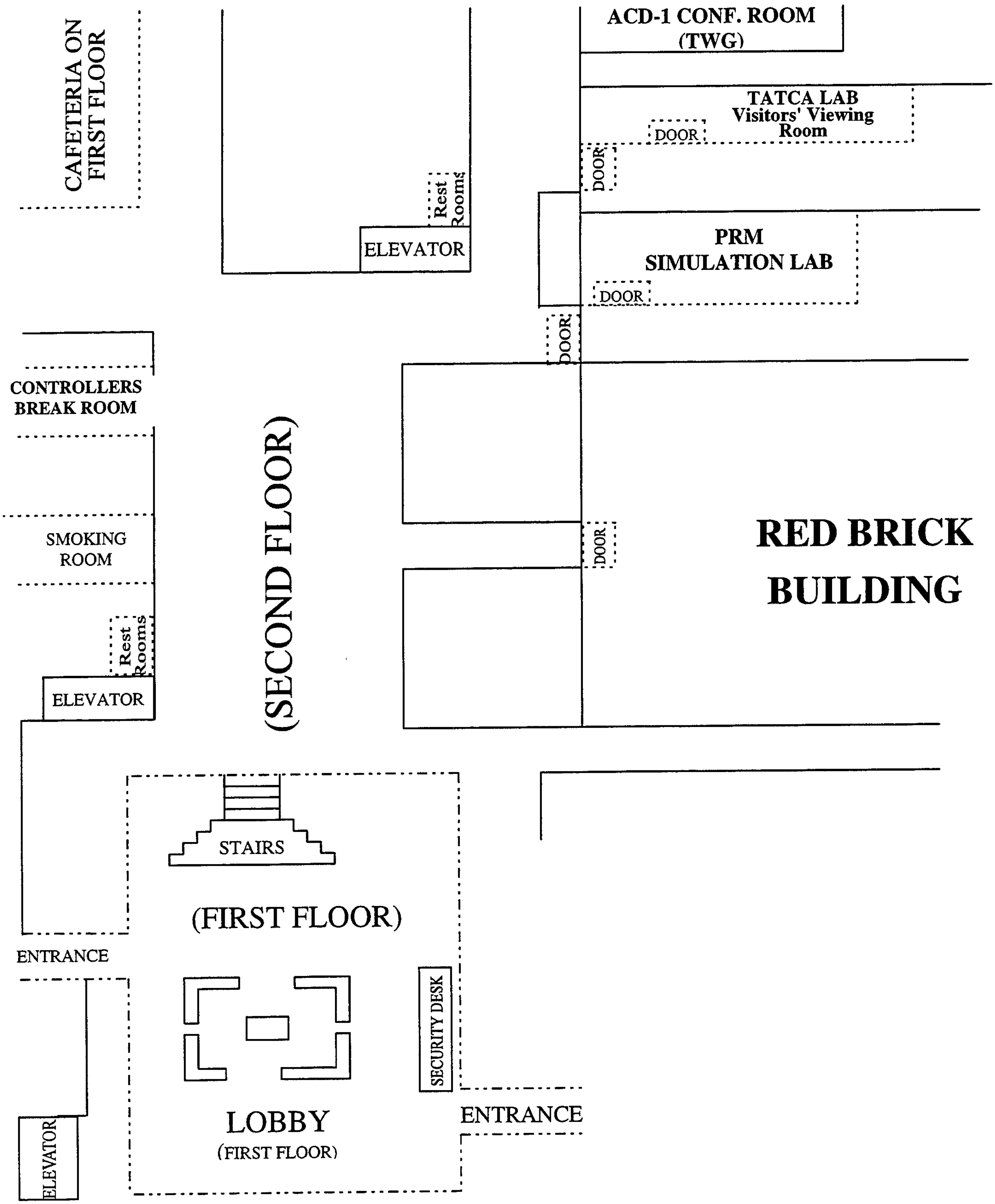
CONTROLLER SCHEDULE
October 16-27, 1995

DATE	RUN	18R	18L
10/26	25a	L	G
Thursday	25b	H	I
	26a	J	K
	26b	H	G
	27a	L	K
	27b	I	J
10/27	28a	G	H
Friday	28b	I	J
	29a	K	L
	29b	G	I
	30a	H	K
	30b	J	L

CONTROLLER QUESTIONNAIRES

- You will be required to complete three different types of questionnaires during and following the simulation:
  - Blunder Statement
  - Controller Questionnaire
  - Post-Simulation Questionnaire
- You will receive a Blunder Statement from the technical observer monitoring your position following each run in which two aircraft come within a close proximity of one another.
- You will receive a Controller Questionnaire from the designated technical observer at the end of each day.
- You will receive a Post-Simulation Questionnaire from the designated SRC representative during the de-briefing session on the last day of your participation in the simulation.
- It is important that you answer the questions carefully and return the completed questionnaires to the designated SRC representative in a timely manner.

FAA TECHNICAL CENTER LAYOUT



Appendix E

Pilot Briefing

PILOT BRIEFING

FAA APPROACH SIMULATION

October 16-27, 1995

FAA Technical Center

Atlantic City International Airport, NJ

INTRODUCTION

- Welcome to this FAA simulation. Your cooperation in this project is greatly appreciated. By participating in this simulation you will assist in providing data that will help enhance air safety and increase the arrival capacity at many airports nationwide.

- In this simulation you will be flying about 4 to 6 ILS approaches per hour to a fictitious airport called CHARLIE INTERNATIONAL. You will be positioned at a point located about 20 NM from the threshold at an intercept heading of 20 degrees to the localizer. You will be using the simulator headset and microphones through which you will hear ATC and other aircraft. All the necessary approach plates will be provided.

- We will be videotaping and sound recording the entire simulation. Pilots and their airlines will not be identified. Videotaping has proved to be a helpful tool to non pilot researchers who are unfamiliar with cockpit procedures and who do not realize the workload involved during final approach.

- We will request your social security number and pilot license number for payroll purposes only. You will receive a check 5 to 6 weeks after completing this simulation. If you do not receive payment within 6 weeks, please call the SRC Pilot Group at [redacted]

- Thank you once again for your participation. We look forward to working with you.

FLIGHT SIMULATOR PROCEDURES

- The site coordinator will be your contact. Refer to your confirmation letter for his name and phone number.
- Before each approach the site coordinator will provide you with a card containing the following information:
  - **Call sign** - this will probably be another airline other than your own.
  - **Transponder code** - it is very important to squawk the proper code since this is used in exchanging data with the FAA Technical Center.
  - **Altitude** - this will be the same as the intercept altitude on the approach plates provided at the simulation briefing.
  - **Airspeed** - the given IAS must be maintained to the OM, unless otherwise directed by ATC.
  - **Aircraft type** - most of the time the aircraft on the card will be different than the simulator you are flying. This will present ATC with a variety of aircraft on their display. You will still fly the simulator as you would normally.
  - **ILS Localizer and Tower Frequencies** - these correspond to frequencies found on the approach plates and are displayed on the card for your convenience.
  - **ATIS** - weather will remain the same for each two hour period and the only difference in the three ATIS cards will be the wind.
  - Please use the simulator pre-release checklist to ensure each of the above items is set.

- The site coordinator will specify whether the approach will be flown using a coupled autopilot, or handflown using the flight director. For those pilots flying the General Aviation simulator you may be requested to fly a raw data approach.

- Pilots will be provided with the required experimental approach plates which will vary slightly from the current JEPPESEN format. These plates represent our fictitious airport called CHARLIE INTERNATIONAL.

- You will be released from position freeze on a 20 degree intercept heading to the localizer at about 20 NM from the threshold.

- When released you must assume you have just been told by Approach Control to contact Charlie tower when established on the localizer and about 17 miles out. You will remain on the same frequency during the entire approach phase.

- The site coordinator will tell you when each approach exercise ends.

- The site coordinator will assign new altitude, heading, airspeed and transponder code after the approach is completed so that you can setup for the next approach.

PILOT RESPONSIBILITIES

You will be using call signs that differ from your airline, so it is very important to listen carefully for the correct call sign. It will be helpful to repeat the call sign out loud before starting each approach. The index for each approach will have your call sign printed on it. Please put it where both pilots can see it.

- Maintain a sterile cockpit in accordance with the FARs and the approach environment. Remember that cockpit conversation will be recorded.
- If paired with an unfamiliar crew member or a pilot from another company, review and establish individual cockpit duties to be used during all the approaches.
- Complete the approach briefing and any checklists that are required prior to the final check before being released from position freeze.
- Review the simulator pre-release checklist to ensure the correct parameters are set prior to leaving the Initial Point (IP).
- Do not discuss this simulation with other crew members who will be participating.
- Answer questions from the site coordinator after selected approaches.
- Complete the Flightcrew Opinion Survey at the end of your participation.

QUESTIONNAIRE ADMINISTRATION

- At the end of your participation in the simulation, you will complete a Flightcrew Opinion Survey. Only one survey should be completed throughout your participation. Return your completed survey to the site coordinator before you leave the simulator area.
- This is a unique opportunity for today's line pilot to participate in the research and the development of ATC procedures. Any comments, recommendations, or ideas provided from your direct participation will be used to form a foundation that will help shape the future of the National Airspace System.

- SIMULATOR PRE-RELEASE CHECKLIST

TRANSPONDER...______SET

INTERCEPT HEADING..______DEG, SET

ALTITUDE..LEVEL______FT, SET

AIRSPEED **TO BE MAINTAINED UNTIL OM**..........______KIAS, SET

LOCALIZER...______SET, FOR RWY______

TOWER FREQ...______SET, FOR RWY______

APPROACH MODE (IF APPLICABLE)..ARMED

AUTOTHROTTLE (IF APPLICABLE)..ARMED

CALL SIGN..______REVIEW

SIMULTANEOUS CLOSE PARALLEL ILS APPROACHES

At 180 kts. an aircraft that has entered the No Transgression Zone can cross the adjacent parallel course centerline in as little as ***NINE SECONDS***. Inattention, or failure to expeditiously comply with a final monitor controller's breakout instructions could result in a midair collision. Remember, you are being broken off the ILS because an aircraft from the adjacent ILS has probably deviated off course and is **HEADING YOUR WAY**. When pilots hear or read the word CLOSE in association with simultaneous parallel approaches, they should be especially aware that any instructions issued by a controller should be immediately followed.

This Flight Operations Bulletin imparts important information necessary for pilots to attain the increased level of pilot awareness required for safe, efficient, simultaneous close parallel ILS approach operations. Important pilot questions of "why", "how will I know", "what can I expect", and "what will I do" are answered. Hopefully, "SIMULTANEOUS CLOSE PARALLEL ILS APPROACHES" will be put on your list of important aviation terms or "buzzwords".

WHY?

Increased crew awareness is necessary because in all probability, there is an aircraft operating on the adjacent parallel localizer course as close as 3400' from your wingtip. Failure to comply with ATC clearances, tune the proper localizer frequency, accurately track the localizer course centerline, or respond to controller breakout instructions in an expeditious manner are all factors that may lead to loss of lateral separation, near-midair collisions, or midair collisions. Attention to detail is mandatory!

HOW WILL I KNOW?

Key words such as **simultaneous** and **close parallel** should alert pilots of the need to increase their awareness level. ATIS will broadcast phraseology such as:

Simultaneous Close Parallel ILS Runways (number) L/R/C Approaches in use.

For a **new approach procedure** the approach plate for close parallel approaches will be titled CLOSE PARALLEL ILS RWY (number)R. For **existing approach procedures** a separate plate will be issued. This separate plate will have CLOSE PARALLEL in parenthesis under the approach name. The plates will also have the note SIMULTANEOUS CLOSE PARALLEL APPROACHES AUTHORIZED WITH RUNWAYS (number) L/C/R HAVING (number of feet) CENTERLINE SEPARATION WITH (number) L/C/R, and GLIDESLOPE REQUIRED.

WHAT CAN I EXPECT?

If you or the aircraft on the adjacent localizer course fail to track the localizer course centerline (or worse yet, track the wrong localizer course!), final monitor controllers with frequency override capabilities will issue instructions. Each runway has a dedicated frequency therefore you **will not** hear final monitor

radio transmissions to aircraft on the adjacent localizer course. The two scenarios requiring final monitor intervention are aircraft deviations from the localizer course centerline, and penetration of the No Transgression Zone by the aircraft on the adjacent parallel localizer course. For aircraft observed deviating from the localizer course centerline or observed to overshoot the turn-on, final monitor controllers will use phraseology such as:

"TURN (left/right) AND RETURN TO THE LOCALIZER COURSE" or "YOU HAVE CROSSED THE FINAL APPROACH COURSE. TURN (left/right) IMMEDIATELY AND RETURN TO THE LOCALIZER COURSE".

When an aircraft fails to respond to final monitor controller instructions or is observed penetrating the No Transgression Zone, the aircraft on the **adjacent** parallel localizer course(s) will be issued breakout instructions such as:

"(A/C callsign) TRAFFIC ALERT (A/C callsign) TURN (left/right) IMMEDIATELY HEADING (degrees) CLIMB/DESCEND AND MAINTAIN (altitude)".

A descending breakout is contrary to what pilots would normally expect but the pilot should be aware that ATC will use it when necessary. If the final monitor controller issues a descending breakout, the descent will not take the pilot below the Minimum Vectoring Altitude (MVA).

WHAT WILL I DO?

To ensure proper preparation for "what will I do" the approach briefing shall address the possibility of an **ATC directed breakout.** The briefing should also include how that breakout will be accomplished. Pilots must comply immediately with all final monitor controller instructions. Having been cleared for the approach pilots are in a land the aircraft mode. For this reason it feels unnatural to be broken off the approach particularly if you have the localizer and glideslope wired. For these reasons, pilots can be tempted to question, or hesitate in complying with the final monitor controller's breakout instructions.

During close parallel approach operations, **immediate** execution of the final monitor controller's instructions is **mandatory**. Remember, you are being broken off the approach because the aircraft assigned to the adjacent parallel localizer course has failed to respond to the final monitor controller's instructions or has entered the No Transgression Zone--the aircraft is heading your way. There is simply not enough real estate between you and the deviating aircraft to execute the breakout in a leisurely manner. For example, at 140 kts ground speed an aircraft is traveling 236' per second!

Pilots must be knowledgeable of aircraft autoflight systems as well as procedures and limitations. This is necessary to avoid slow, or improper aircraft response to an issued clearance. Crew coordination items must be thoroughly understood and briefed prior to commencement of the approach. This is particularly critical for automated cockpits. Remember, during an ATC-directed breakout, you can be given any combination of turn and/or climb/descent instructions.

PILOT AWARENESS

OPEN BOOK TEST

Pilot Awareness Training for Simultaneous Close Simultaneous Parallel ILS Approaches.

1. Close Parallel in describing a simultaneous ILS approach means:

   A. Runway centerlines are less than 4,300' apart.

   B. Runway centerlines might be only 3,400' apart.

   C. There might be someone making an approach to the adjacent runway who is very, very close.

   D. All of the above.

2. If a pilot is flying a simultaneous close parallel ILS approach and the controller tells him to turn off the localizer the pilot should:

   A. Take his time because the passengers don't like sudden maneuvers.

   B. Move the aircraft as quickly as practical to avoid a potential mid-air collision.

   C. Not turn off the localizer, because the instruments read on course and you've been cleared for the approach.

3. Can a controller give a pilot a descending turn off the localizer when the pilot is on an ILS approach?

   A. No, not if the aircraft has captured the localizer and glideslope.

   B. No, all turns off the localizer must be accompanied by a climb.

   C. Yes, provided the aircraft is not descended lower than the minimum vectoring altitude (MVA). If that is what it takes to avoid a collision, the controller will direct a descending turn off the localizer.

Answers:

1. D

2. B

3. C

OPEN BOOK TEST

4. What are the most important things to remember about simultaneous close parallel ILS approaches?

    A. Don't make any abrupt turns because of passenger comfort, and always question every turn off the ILS localizer given by ATC.

    B. If you don't turn immediately off the localizer when directed by ATC, perhaps maybe he'll forget about you and you can get in on time. If the controller is being unreasonable by making you late, stand your ground and don't let him intimidate you, after all you're an airline captain.

    C. There is probably someone very close along side of you making an approach to the other runway. If ATC tells you to turn off the localizer it means that the airplane along side of you is now heading your way and it might hit you unless you move the airplane quickly.

5. When you hear ATC transmit TRAFFIC ALERT, what kind of message is going to follow?

    A. A turn off the ILS for someone because an aircraft on the parallel runway is heading his way.

    B. There is a new ATIS coming up and the controller wants everyone to listen to it.

    C. The highway leading into the airport is really jammed up with cars.

6. How should the briefing for simultaneous close parallel ILS approaches be conducted?

    A. No briefing is necessary.

    B. Use the standard briefing for ILS approaches.

    C. Use the standard briefing for ILS approaches. Additionally brief for the close aspect of the approach, the possibility of an ATC directed breakout and how it should be conducted.

Answers:

4. C

5. A

6. C

This procedure is for simulation purposes only

Breakout Procedure Bulletin

General Discussion:

Closely spaced (less than 4300 feet between parallel runway centerlines) ILS simultaneous approaches have created the need for a breakout procedure. Breakout is defined as an ATC directed departure from an ILS approach prior to reaching the D/H. Before the advent of closely spaced ILS simultaneous approaches, ATC rarely diverted an aircraft from an ILS approach. If a breakout was initiated by ATC, it was usually the result of a spacing problem and not a potential collision problem with another aircraft. It is forecast that closely spaced ILS simultaneous approaches will increase the frequency of breakouts and the spacing between the parallel localizers dictates that a procedure be implemented to reduce the maneuver times of the evading aircraft.

A breakout to avoid a collision is considered to be an emergency-like maneuver and extraordinary steps in the breakout procedure are needed. Although autopilot use is encouraged for a closely spaced ILS simultaneous approach, the breakout procedure will be hand flown. It is very important that the breakout transmission from ATC be followed immediately and the only way this can be accomplished quickly is by disconnecting the autopilot and hand flying the airplane through the maneuver. The pilot must keep in mind that a descent might be one of the options that the controller might use, providing the aircraft is above the minimum vectoring altitude (MVA). The pilot can count on the MVA not being below 1,000' AGL and in all probability the MVA will be considerably higher, because the MVA provides at least 1,000' clearance above obstacles.

Studies have found that using an autopilot for a breakout results in longer breakout times than when the aircraft is handflown through the maneuver. Some aircraft take longer than others when using the autopilot, but for standardization purposes, the policy will be to make all ATC directed breakouts without the autopilot connected.

This procedure is for simulation purposes only

Breakout Procedure Bulletin

The following procedure is to be used when conducting an ATC directed breakout from a closely spaced ILS simultaneous approach:

PILOT FLYING (PF):

- Disconnect autopilot and point the aircraft in the direction the controller has directed (including climb or descent).
- Monitor speed and consider disconnecting autothrottles (if applicable) or overriding with manual throttle inputs.
- Command to clean up aircraft using normal procedures.

PILOT NOT FLYING (PNF) - catch up the flight director to the aircraft flight path:

- Turn off both flight directors
- Turn on PNFs flight director
- Set new heading.
- Set new altitude
- Make other inputs as necessary to match the flight director with the desired flight path.
- When PNFs flight director matches the desired aircraft flight path, turn on PFs flight director.

NOTE: It is important that the PNF turn off the flight director of the PF, so that the PF does not have to fly through the flight director. It is not desirable to have the flight director telling the pilot to do the opposite of what ATC wants the pilot to do.

THIS BREAKOUT PROCEDURE SHOULD BE BRIEFED ALONG WITH THE NORMAL APPROACH BRIEFING PRIOR TO ALL CLOSELY SPACED SIMULTANEOUS ILS APPROACHES.

BREAKOUT PROCEDURE

OPEN BOOK TEST

1. When accomplishing a hand flown breakout the PF should:

   a. Wait for the PNF to setup the flight directors before taking any action.

   b. Immediately turn and point the aircraft (climb or descent) as directed by the controller.

   c. Leave the aircraft coupled to the Autopilot.

2. The PNF needs to turn off:

   a. Only his Flight Director.

   b. Only the flight director of the PF.

   c. Both flight directors

3. If the approach is being made on the autopilot:

   a. A breakout should be conducted on the autopilot.

   b. A breakout can be done by using the autopilot or by handflying the breakout.

   c. All breakouts must be handflown.

4. The PNF should turn on the flight director of the PF:

   a. Immediately.

   b. No urgency, the PF is experienced and has no need for a flight director.

   c. As soon as the his flight director matches the desired aircraft flight path.

5. (Answer only if aircraft has autothrottles) During hand flown breakouts the PF should:

   a. Always keep the autothrottles engaged.

   b. Consider disconnecting the autothrottles and applying manual inputs.

   c. Never use autothrottles.

1. - B

2. - C

3. - C

4. - C

5. - B

ATIS 'A'

THIS IS CHARLIE INFORMATION ALPHA.

WEATHER MEASURED 200 OVERCAST, VISIBILITY ONE HALF, FOG, TEMPERATURE 59, DEW POINT 54, WIND CALM, ALTIMETER 29.92. SIMULTANEOUS CLOSE PARALLEL ILS RUNWAYS 18L AND 18R APPROACHES IN USE.

ADVISE YOU HAVE ALPHA

Automatic Terminal Information System (ATIS) Card

Appendix F

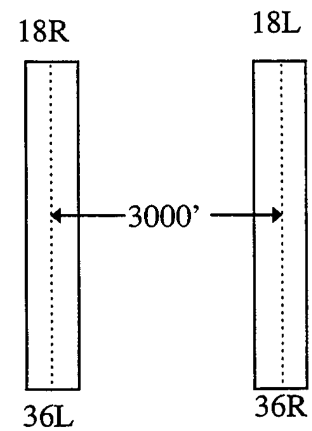
Approach Plates and Information Page

CHARLIE, USA
CHARLIE INTL

SIMULTANEOUS CLOSE PARALLEL APPROACHES

Pilot Briefing Checklist:

1) Breakout briefing, hand flown breakout
2) Check altitude below which no descending.breakouts will be given.
3) Respond immediately to breakout instructions.



Runway Centerline Separation
Charlie International

The ATIS broadcast will advise pilots when simultaneous close parallel ILS approaches are in progress. **If unable to meet the requirements below, notify ATC immediately.**

Before initiating a simultaneous close parallel ILS approach, this information bulletin must be read and the following requirements met.

1. **View the FAA video, *RDU Precision Runway Monitor: A Pilot's Approach.***
2. **All ATC directed breakouts (a vector off the ILS prior to the D/H) are to be HANDFLOWN, unless company procedures and/or aircraft flight manual dictate otherwise.**

BREAKOUT DESCENTS:

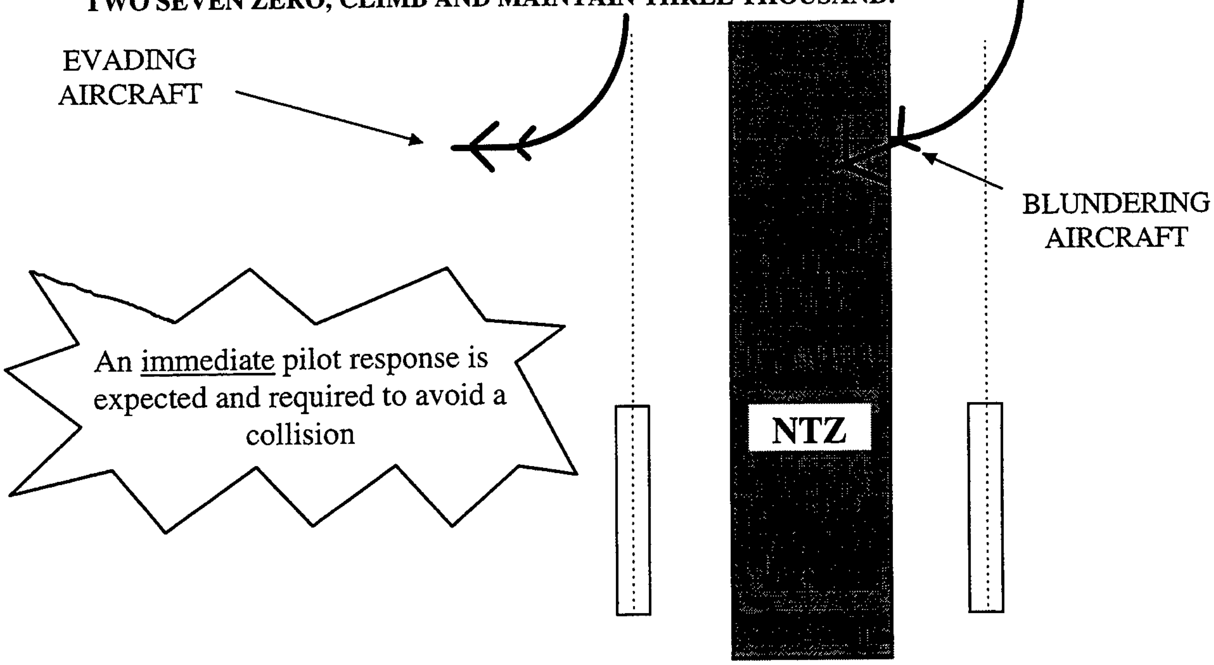
Pilots should be aware that the controller may give a descending breakout. In no case will a descent be given below the MINIMUM VECTORING ALTITUDE (MVA). The altitude below which no descending breakouts will be given by ATC is noted on the approach plate.

CONTINUED ON OTHER SIDE

PHRASEOLOGY:

Every effort will be made by the tower and monitor controllers to return aircraft to the localizer that have overshot or strayed from the final approach course. When an aircraft penetrates the NO TRANSGRESSION ZONE (NTZ), it is <u>mandatory</u> for the controller to breakout aircraft on the adjacent approach course that might be in danger. The phraseology for the breakout will be as follows:

> TRAFFIC ALERT (aircraft callsign) turn (left/right) IMMEDIATELY heading (degrees) Climb/descend and maintain (altitude) .
>
> Example:
>
> **TRAFFIC ALERT, ALL AMERICA 123, TURN RIGHT IMMEDIATELY HEADING TWO SEVEN ZERO, CLIMB AND MAINTAIN THREE THOUSAND.**



The pilots receiving this message will not be forewarned by hearing the transmissions to the blundering aircraft, because each approach course is being monitored by a separate frequency. When a pilot is told to breakoff the approach, the pilot must assume the worst: that an aircraft from the adjacent localizer is heading his way and that the breakout <u>must</u> be started immediately and continued as rapidly as safety allows. An <u>immediate</u> pilot response is expected and required to avoid a possible collision.

11-1A

CHARLIE, USA

CHARLIE INTL

ILS Rwy 18R

(CLOSE PARALLEL)

LOC 108.5

(NOTE: NO IDENT)

TWGESSEN CHARTS 16 OCT 95

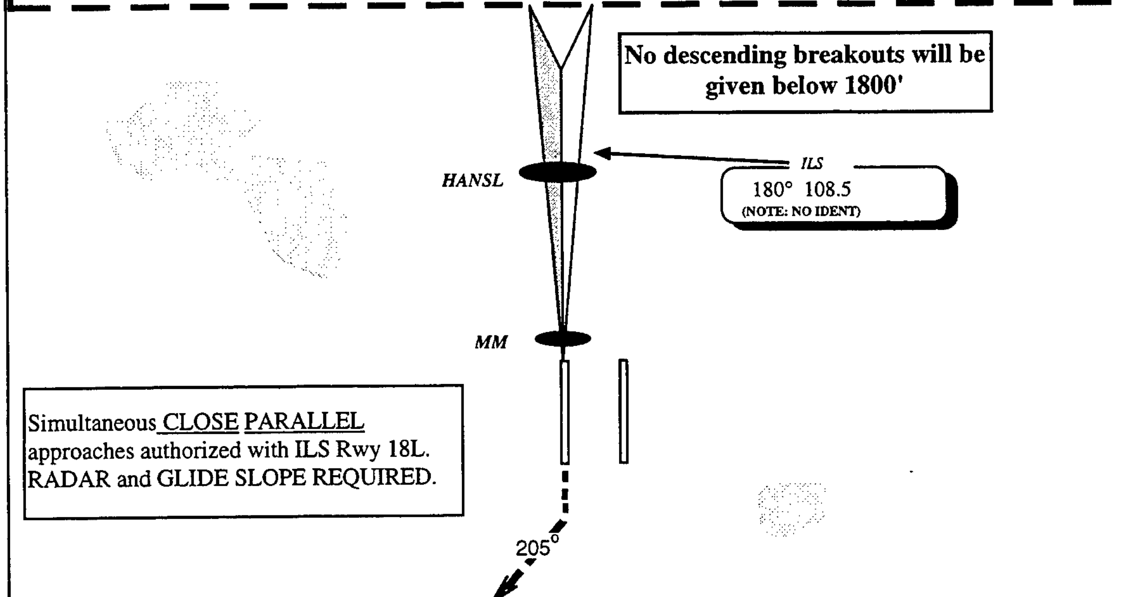
ATIS Arrival	**XXX.X**	
CHARLIE Approach (R)	**XXX.X**	
CHARLIE Tower Rwys	**18R-36L**	**127.2**
	18L-36R	126.8
Ground	**121.9**	

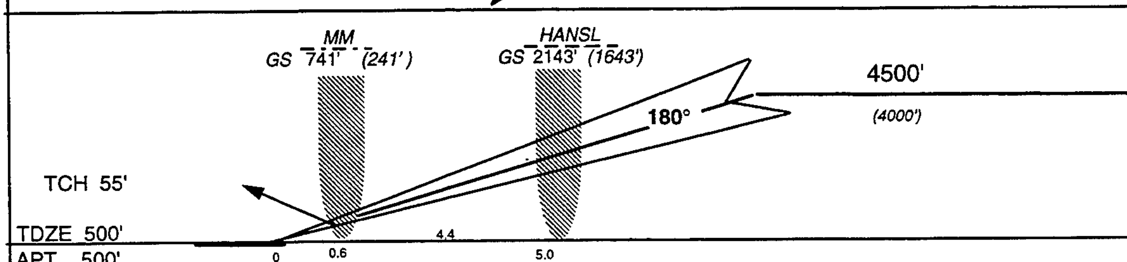
2000'

MSA

HANSL OM ***Apt. Elev*** **500'**

11-0 MUST BE READ PRIOR TO FLYING THIS CLOSE PARALLEL APPROACH





MISSED APPROACH: Climb to 1000' then climbing right turn to 5000' via heading 205° and expect radar vectors.

	STRAIGHT - IN - LANDING RWY 18R ILS DA(H) **700'** (200')			LOC (GS Out)	CIRCLE - TO - LAND MDA
	FULL	TDZ or CL out	ALS out		
A B C D	RVR **18** or 1/2	RVR **24** or 1/2	RVR **40** OR 3/4	**Not Authorized**	A B C D **Not Authorized**

Gnd speed - Kts		70	90	100	120	140	160
GS	3.00°	378	486	540	648	756	864

TWGESSEN CHARTS 16 OCT 95 11-2A

CHARLIE, USA

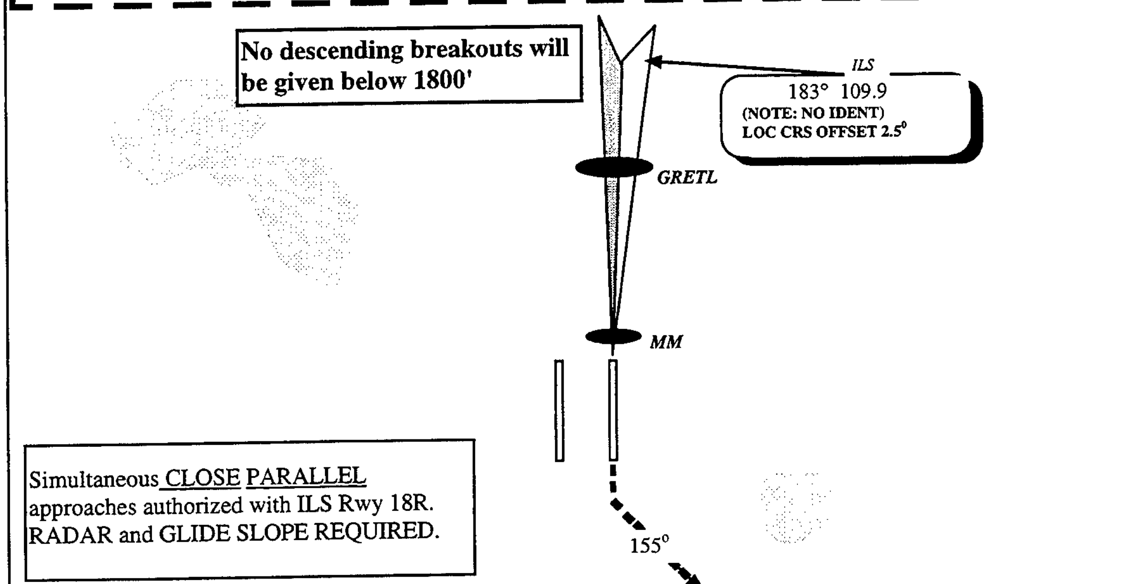
CHARLIE INTL
ILS Rwy 18L
(CLOSE PARALLEL)
LOC 109.9
(NOTE: NO IDENT)

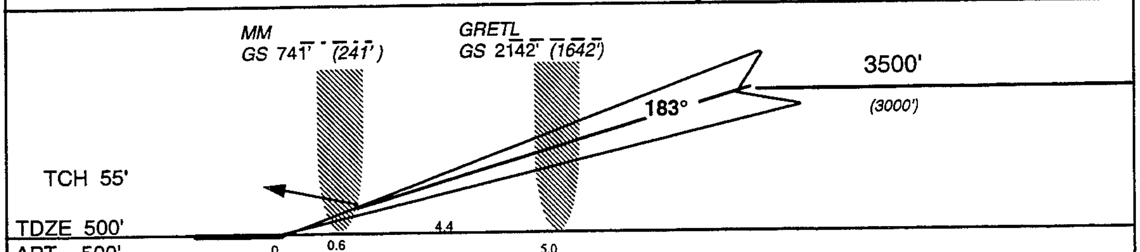
ATIS Arrival		**XXX.X**
CHARLIE Approach (R)		**XXX.X**
CHARLIE Tower Rwys	**18L-36R**	**126.8**
	18R-36L	127.2
Ground		**121.9**

2000'
MSA
GRETL OM

Apt. Elev **500'**

11-0 MUST BE READ PRIOR TO FLYING THIS CLOSE PARALLEL APPROACH





MISSED APPROACH: Climb to 1000' then climbing left turn to 4000' via heading 155° and expect radar vectors.

	STRAIGHT - IN - LANDING RWY 18L ILS DA(H) **750'** (250')			LOC (GS Out)
	FULL	TDZ or CL out	ALS out	
A B C D	RVR **18** or 1/2	RVR **24** or 1/2	RVR **40** OR 3/4	**Not Authorized**

CIRCLE - TO - LAND	MDA
A B C D	**Not Authorized**

Gnd speed - Kts		70	90	100	120	140	160
GS	3.00°	378	486	540	648	756	864

Appendix G

Blunder Distribution Results

TABLE G-1. SUMMARY OF TEST CONDITION GOALS AND ACTUAL RESULTS.

TEST CONDITION	Goal (%)	Attained (%)		
		Real-Time	BRM	ASAT
Blundering Aircraft Communications Status				
No Communications	80.0	79.6	100.0*	100.0*
Communications	20.0	20.4	0.0	0.0
Blundering Aircraft Flight Path				
Maintain Altitude	50.0	53.0	50.0	50.0
Descend	50.0	47.0	50.0	50.0
Blundering Aircraft Start Course				
18L	50.0	47.7	50.0	50.0
18R	50.0	52.3	50.0	50.0
Blunder Distribution along Final Approach Course				
1-3 nm	18.0	16.1	18.2	28.6
3-5 nm	18.0	16.8	18.2	28.2
5-7 nm	18.0	20.1	18.2	12.1
7-9 nm	18.0	16.7	18.2	12.6
9-12 nm	28.0	30.3	27.2	18.7
Aircraft Type (Involved in Blunders)				
Jet	65.0	65.1	68.0	65.0**
Heavy Jet	30.0	29.9	25.8	30.0**
General Aviation	5.0	5.0	6.2	5.0**
Aircraft Flight System (Involved in Blunders)				
Glass (Digital)	60.0	61.5	58.6	60.0**
Conventional (Analog)	35.0	33.5	35.2	35.0**
General Aviation	5.0	5.0	6.2	5.0**

* The BRM and ASAT simulations only used No Communications blunders in their TCV rate calculations in order to simulate worst-case situations.

** Actual percentages were not available, however, blunder distributions were selected based on the percentage goals.

Appendix H

Site Coordinator Briefing

SITE COORDINATOR BRIEFING MATERIALS

FOR

FAA MPAP TWG SIMULATION

October 16 - 27, 1995

FAA Technical Center

Atlantic City International Airport, NJ

WELCOME

You will be participating as a site coordinator in the simulation of close parallel simultaneous ILS approaches to parallel runways at a fictitious airport, Charlie International. The runways of this fictitious airport are 3000' apart and one of the runways has a 2 1/2 degree offset with the runway centerline. This Site Coordinator Instruction Package contains instructions about how to conduct the simulation, how to brief the pilots, how to administer the pilots and how to train the crews.

As the site coordinator, your responsibilities include insuring pilot contracts are complete and correct, briefing the pilots, administering the pilot training, providing pilots with ATIS card and run number information, documenting the approach, administering questionnaires, video taping each approach, and having the pilots complete a survey. In addition, site coordinators shall submit a brief report containing their observations during the simulation and operational issues that it addressed. You are the best source of information concerning the pilot and cockpit perspective of the approach operation being simulated. Please record any and all observations carefully and completely. At any time during the simulation, if you have a question, please do not hesitate to call a SRC representative.

NOTICE

There have been changes made to this document since the last simulation. We marked most of the major changes with a vertical bar in the margin. Please read over the entire document to refresh your memories. You might get some questions from the pilots with regard to going over the same material and filling out a similar survey to the one they filled out in August. Just tell them that the simulation is different and we want them to do everything again with the exception of viewing the film (we are giving them the option of not viewing it if they viewed it in August). The survey is especially important because the pilot will be answering the questions from a different point of view.

GENERAL INSTRUCTIONS

1. It is <u>very important</u> that a professional atmosphere be maintained throughout the simulation, especially during final approaches. When the simulator is in motion, a sterile cockpit is required. Remember, the pilots are on video. A number of people will be reviewing this simulation and many are especially concerned with the professionalism of the participants. It is essential for the simulation to be conducted as close to real world as possible.

2. Please do not use the simulator phone lines at any time for calls other than to the Test Director at the FAA Technical Center or to contact a technician outside the simulator.

3. Please insure pilots comply with headset requirements and they use the boom mike if supplied. The use of the speaker might produce feedback into the video sound and the boom mike on some of the simulators is the source for the cockpit conversation recording.

4. You will be video taping each two hour session during the simulation. It is important to insure that communications between ATC and the pilots are captured on the tape, as well as crew interaction and cockpit conversations. During the last simulation, several simulators did not record radio traffic. Please check your tapes to determine if your site is recording ATC. Further instructions on video taping can be found later in this document.

5. Prior to each approach, stress call sign recognition with the pilots. Require each pilot to verbalize the call sign without reference to the index card and then have the pilots place the card so that each pilot can see it. We know that there will be lots of stumbles over the call sign, but by using this procedure this problem can be minimized.

6. On each approach, complete the Simulator Pre-Release Checklist. We have put the checklist and the breakout questionnaire in a plastic page protector located in the back of the 3-ring notebook.

7. The pilot flying should alternate with each approach. If there are two first officers in the seats, it's OK if they switch seats, so that the pilot flying will be in the seat in which he is most comfortable.

8. It is <u>very important</u> that each approach is started at the scripted time and the aircraft are flying the assigned speed for the approach number. This speed must be maintained to the outer marker unless changed by ATC. You are authorized to tell the pilots to speed up or slow down if the speed is not in the ballpark. You are <u>not</u> authorized to help in any other way during the approaches.

9. At the end of each day, fax all of the site coordinator log sheets for the day to [redacted]. Please write legibly and remember that neatness counts. Retain the originals as they will need to be mailed at the end of the simulation. If no fax is available, include a copy of each log sheet when you mail the contracts and expense reports.

10. You will mail the original contracts and expense reports for each pilot once or twice a week to [redacted] via priority mail. We can't start the pay process until we receive those papers.

DAILY SCHEDULE

Training:	1100 - 1200 **EDT**
1st Run of Day:	1200 - 1400 **EDT**
2nd Run of Day:	1430 - 1630 **EDT**
3rd Run of Day:	1745 - 1945 **EDT**

Please note that the above times are ***EASTERN DAYLIGHT TIME.*** The schedule will probably be modified each day. The times are listed here just as a guide.

PILOT ADMINISTRATION

Pilot List And Schedule

You are given a schedule and a list of the pilots who were assigned to your simulator. We tried to get two captains and one first officer for each day. Since only approaches are being conducted with no emergencies, we feel that the first officers can fly from the left seat in the event we couldn't get the required captains. Each pilot will fly two periods. If there are two captains, one of the captains will relieve the captain for one period and the first officer for one period. It is not necessary for the pilot who does not fly the last period to stay around after he has completed all the necessary paperwork, including the pilot survey on his last day. It is also not necessary for a pilot who has completed the training and doesn't start until the second period, to come in and wait around to fly. You decide how to schedule the pilots.

If someone doesn't show up, try to get a replacement from your pilot list. Contact [redacted] for more names. You should ask the pilots who did show up if they know of anyone who would like to participate. As a last resort if two pilots don't show, you can fly to save the simulator period, but have the scheduled pilot fly all the approaches.

Pilot Code Assignment Sheet

You will assign a separate letter code to each pilot at the beginning of his/her participation in the simulation. There is a sheet on which this information should be entered. The pilot will be referred to by this letter code on the log sheets.

Purchased Labor Agreement, Expense Account Form And Video Release Form (Samples of filled out forms included)

Purchased Labor Agreement: have the pilot fill in the name, address and telephone number at the top, sign the form after acknowledgment and insert his social security number and pilot certificate number. You will fill in the dates, number of days pay and the total amount. If, for some reason, only two pilots show up, pay the two pilots 1 1/3 days pay for that day.

1 Day - [redacted]

1 1/3 Day - [redacted]

Expense Account Form: The pilot will fill in his name and address on the top and sign and date the form on the bottom. IF A PILOT FLIES ON DAYS OF BOTH WEEKS, HE HAS TO SIGN TWO FORMS, ONE FOR EACH WEEK. Explain that the name and address the pilot fills in will be the one our accounting department uses, so they should be careful that it is readable. You will fill in the numbers on the form as per the enclosed sample.

Video Release Form: Have the pilot print his name, sign and date the form.

You should find a copy machine you can use and make copies of the contract and expense account form for you and for the pilot. You will send the originals back to us by US priority mail every few days so that we can get the paying process started. The copy should be sent back at the end of the simulation with all the other materials. Tell the pilots to call the SRC Pilot Group if they do not get a check within 5 to 6 weeks from the end of the simulation.

This signing in process can take a few minutes. The first day there will be training, so don't waste time. One hour is calling it close so it is important to get started right away.

TRAFFIC SAMPLES, TRAFFIC SAMPLE SCHEDULE, ATIS CARD AND PREPARING CARDS FOR EACH APPROACH

Three two hour simulator sessions will be flown each day. Each two hour session will be referred to as a RUN. RUN #1 will be the first two hour period on the first day, RUN #2 the second two hour period, etc., continuing through the simulation for a total of 30 RUNS (10 days with 3 runs each). The last run of the two weeks will be RUN #30. There are four sets of TRAFFIC SAMPLES, 201, 202, 203 and 204. There is a TRAFFIC SAMPLE SCHEDULE which lists for each two hour RUN the TRAFFIC SAMPLE that will be used. The TRAFFIC SAMPLES are the scripts for the two hour simulations and consist of a list of approaches. Each approach is identified by a number which is referred to as an INDEX NUMBER. In front of many of the INDEX NUMBERS is a simulation site and how the approach will be flown (autopilot, hand fly, raw data -GAT only). The individual INDEX NUMBERS that are identified by your simulator will be highlighted and are the ones that your simulator will fly. Cards have been prepared for each INDEX NUMBER for your simulator. Each site will have a clock synchronized with the FAA Technical Center that you will use to place the aircraft into the problem according to the time listed on the TRAFFIC SAMPLE INDEX NUMBER. It is the responsibility of the site coordinator to verify that the cards are in the correct order and are correct. Other information included on the TRAFFIC SAMPLE includes:

AIRCRAFT TYPE - this has no relation to your simulator type and is what will appear on the radar tag. You might be in a MD88 simulator and be assigned a run number that is a B-727. The pilots will always fly the simulator as they normally would even though the aircraft type is different than the simulator. The reason for this is to fool the controllers as to which targets are simulators and which targets are being controlled by a computer operator. The pilots should be aware that the controller might refer, in this case, to your target as a 727 when talking to another aircraft.

IAS - this speed is to be held to the outer marker unless changed by ATC.

CALL SIGN - the call sign will most probably be different than the call sign used by the pilot's company. Have each pilot repeat the call sign out loud before each approach.

INITIAL ALTITUDE - this will be the altitude at simulator release and the altitude of localizer and glide slope intercept.

RUNWAY ASSIGNMENT- this will show the pilot which approach plate to use.

TRANSPONDER CODE - it is VERY IMPORTANT to set prior to each approach. The transponder code is sent over the data line to Atlantic City and identifies the simulator.

HAND FLOWN, AUTOPILOT, RAW DATA - describes how the approach will be flown. All simulators with exception of the General Aviaiton Trainer (GAT) will only use coupled autopilot and hand flown (using flight director) approaches. Each approach will be assigned one of these methods.

Before you hand the card to the pilots, hold it up in front of the video camera and repeat out loud the index number. This will facilitate identifying the index number when the tapes are reviewed.

Sometimes the FAA Tech Center will call during the simulation and give you a different index number to fly. You will prepare a new card for that index number, give it to the pilots and release the simulator at the new appointed time. A highlighter has been provided for highlighting your index number lines.

ATIS Card: The TRAFFIC SAMPLE will list the ATIS (A, B or C) to be used for each two hour run. The only difference in the ATIS will be the wind. You will have to put the wind into the simulator setup before each run begins. You have been supplied two cards for each ATIS.

VIDEO TAPING INSTRUCTIONS

Each two hour session must be video taped. These video tapes will be used during data analysis, and are a very important part of the entire data collection process. Before each day begins, please be sure that the equipment is working properly. At the end of each day run the tape a few minutes to see if it recorded OK.

Please insure each video tape and each video tape cover is labeled with the following information:

Site, Date, Run Number (1,2,3 or 4).

You will be sent enough video tapes for the entire simulation. In case you need more tapes, buy them and put it on your expense account.

The purpose of the video is to capture crew interactions, communications between the pilots, including pilot conversation between approaches, and communications between the cockpit and ATC. We know that we won't be able to see individual instruments, but we will be able to see the pilots' arm and hand movements.

Start the recording at the beginning of each two hour session and stop at the end of the session. To insure that you do not run out of tape in the middle of a two hour run, please record on extended play format (or the slowest speed available) and periodically check how much tape is left. Know what the slowest speed available is and use it. In Atlanta, for example, the slowest speed available will fill up the tape in four hours. In this case, the second two hour period is critical with regard to running out of tape. During the fourth hour the camera should be turned

off a minute after the breakout turn is completed or when the sim is stopped in case there was no breakout. Do not forget to hold the index card in front of the camera to identify the run. This is important for the people who are reviewing the 210 hours of tape. If you are told by Atlantic City that the previous approach was a midair (see following section), hold up the TCV shape in front of the camera lens for about five seconds. This will help the viewer find the approach that resulted in the midair collision when the viewer is using the VCR fast forward mode.

You may wait until the end to send all the tapes to SRC or you may send them back at the end of each week. Mail them back in the boxes they arrived in and use the FEDEX prepaid labels in your packet of materials.

SITE COORDINATOR LOG

A new site coordinator log has been developed. The major difference is that the sheet is divided into two sections, a section on the left where every approach will be recorded and a larger section on the right where breakout information or any other abnormal information will be recorded. Any abnormalities noted during the breakout should be recorded in the Abnormalities column. A simple number code of common mishaps may be found at the bottom of the log to make the entering of comments easier, but if you don't find a proper code, write in your comment in the area provided.

Please fill in the date, run number, traffic sample and wind condition next to the designated spaces at the top of the log. On occasion, the system may fail during a run and be restarted with the same Run Number. If this occurs, for example in Run Number 4, the traffic sample would remain the same, and the Run Number would become 4-2. Always coordinate with the FAA Technical Center at the beginning of each run to verify the Run Number and the start time of your first approach. Please use a new log sheet at the beginning of each two hour run.

The following sections will describe the information required for each column on the Site Coordinator Log:

Index Number - Refers to the index number on the Traffic Sample sheets. It is the sequential approach number.

Call Sign - Refers to the ID number of the aircraft.

Pilot ID - Refers to the letter code assigned to the pilot.

Breakout Questionnaire

After each approach when the pilot was vectored off of the final approach course prior to the D/H, you are to ask the pilots the questions on the Breakout Questionnaire which is located in the plastic envelope on the reverse side of the pre-release checklist. Record the responses in the appropriate columns on the Site Coordinator Log using the appropriate codes. There should be only one set of responses for each approach. Either get a

consensus of both pilots or the answers from the pilot flying. Note: DO NOT ACCEPT zeroes or half numbers, just whole numbers.

YOUR MOST IMPORTANT DUTY - Each time there is a mid-air collision (technical criteria violation or TCV in simulation study jargon) during one of the approaches, all aspects of the approach are looked at in detail by a number of people from System Resources Corp. There are three video tapes (the cockpit, the radar screen and the controllers) that are scrutinized for each TCV. The logs of the controller observers and the pilot observers are also gone over in detail. We try to determine why the TCV happened and what we can do to prevent it from happening again. After each TCV is scrutinized by SRC personnel, then the TCV data is presented to a large group consisting of people from FAA Headquarters, FAA operations, FAA Technical Center and several government contractors. Your pilot observer log will be viewed and the video of your simulator pilots will be shown to this large audience. The point is that in spite of all the work that you have done, a couple of entries in your simulator log is what is going to be looked at in detail. In the past, the site coordinator never knew when a midair or TCV occurred. We thought that during this simulation we will call you when you have been involved in a TCV. The reason for this is that you might put down more information if you knew that the breakout resulted in a mid-air. However, we do NOT want you to tell the pilots about the TCV. We hope that you put down as much information as possible after each abnormality, but make an extra effort to put down as much as you can recall after a TCV.

LIST OF CONTACTS

A list of flight simulator contacts and coordinators, simulator facility and cab phone numbers, test director primary and backup numbers has been provided. Each simulator site has been assigned a FAATC Line. You are to use this phone number if you need to reach the FAA Technical Center test director at any time during the simulation. In the event the number assigned to your simulator site is busy, please use the backup number provided for your site. **Each day before the simulation starts you should telephone this number and establish contact with the FAA Technical Center.**

PILOT BRIEFING INFORMATION

A Pilot Briefing pamphlet was sent to each pilot participating. We have included a few extra copies in your materials in case a pilot signed on too late to receive one. We have included a copy of the letter that accompanied the pilot briefing packet so you know what information the pilots were supplied.

TRAINING

The pilots will be trained before their first ride in the simulator. The training will consist of watching a video, reading a Pilot Awareness Training Bulletin, and taking a short test. All the pilots except the B-727 and GAT pilots will also read a Breakout Procedure Bulletin and take a short test on that subject.

Video

Show the pilots the video, *RDU, Precision Runway Monitor: A Pilot's Approach.* Make sure that the door to the room is shut so that they are not disturbed. The video runs for 12 minutes. We expect that most of the pilots will have viewed the video during the previous simulation. They are not required to see it again, but may view it if they wish. It also might be a good idea for you to review it again.

Pilot Awareness Training Bulletin and Procedures Training Bulletin (if applicable)

After the video, hand out the approach plates, airport information page, Pilot Awareness Bulletin and the Procedures Training Bulletin (if applicable - only for glass cockpits). Do not hand out the tests at this time, just tell them that there will be a test.

The bulletin type training is similar to a pilot going to work and finding a training bulletin in his mail box together with a test. The pilot would read the bulletin, take a short test and hand it in to the chief pilot so that the pilot's training records could reflect that he had received training. You are not an instructor, but you can answer questions if asked. This would be similar to a pilot with a question about one of the training bulletins going into see one of the check pilots to get an answer.

The pilots will grade their own tests. The answers are on the back of the tests. Don't hand out the tests until they read the bulletins and don't tell them they are self-graded until you hand out the tests. We don't need the tests back, but please check to insure that they got the correct answers. We found in one of our previous simulations that a significant number of pilots put down the wrong answer because the question was not covered in the training. Note if more than one pilot gets one of the questions wrong.

PILOT SURVEY

On a pilot's last day, he will fill out a survey. Please stress to him that it is very important to put down all the comments that come to mind. Make sure that the pilot leaving early finishes the survey before he leaves. DON'T LET HIM LEAVE WITHOUT COMPLETING THE SURVEY. The survey is a very important part of the simulation and we have used the pilots' comments to get procedures changed in the past. If we think that something is needed for safety and it costs money to implement, it is much easier to get approval if we have support from the pilots taking part in the simulation. Many of the procedures in this simulation are a result of pilots' comments in the past and were not achieved easily.

FINAL REPORT

We need a final report from you to help us in this simulation and in future simulations. We would like a summary of your site, what went wrong, what went right, what we should have done, what we did wrong, what you observed as the problems with the close parallel approaches, what you would recommend to make them safer, what we could do to make the simulations more realistic, etc. You will be on the front lines observing first hand, so your comments will be especially pertinent. Some of you gave very detailed reports in August and we truly appreciate the time and effort you made. We hope that every site coordinator gives us a detailed report after this simulation. This time you will know that your simulator was involved in a midair collision and can probably give us a better insight as to why. You might be able to give us ideas about better training, better pilot technique, better controller controlling, etc. You might conclude that 3000' is too close. You might conclude that all is OK and we should implement this tomorrow. You might be able to pick up something that we didn't observe before (a site coordinator in August picked up a safety item we never knew existed). Any and all of your comments are appreciated. You never can tell us too much.

THE END

At the end of the simulation, pack up all the materials and send them back to [redacted]. We should already have a signed copy of your Purchased Labor Agreement. If you have expenses, put all your receipts in an envelope along with a detailed accounting of your expenses, SIGN THREE expense sheets [redacted] and send it all back to SRC. We will fill in the expense reports for you with your receipt information. All telephone calls must be identified with date, who called, why and from where to where. We will do our best to get your pay as soon as we can. We realize that some of you have put out a considerable amount of money and need to be reimbursed without delay.

Those of us at SRC and our customers at the FAA join to thank you for your participation. You have made a difference in something that might or might not happen in the future of aviation. Not many pilots get that chance. Close parallel approaches might not happen at 3000' runway separation, but if they do or don't you have had an input into the final decision.

18R	"PA31"	IP-TIME: 1:21:58
	"N84986"	
HDG: 200°	ALT: 4500'	IAS: 126 kts
LOC: 108.5	TOWER: 127.2	SQUAWK: 2136
	Raw Data	
SITE: GAT	SAMPLE: 201	INDEX #: **95**

Approach Information Index Card

Appendix I

Controller Questionnaires

CONTROLLER QUESTIONNAIRE

October 16-27, 1995

PARTICIPANT CODE ________ DATE __________

Please complete the following questionnaire based upon your experiences throughout the day (practice runs excluded). Please refer to the list of definitions on the back of this questionnaire, if necessary. Should you have any questions, ask the SRC representative.

---

1. Rate the level of **stress** experienced to resolve blunders.

1	2	3	4	5
minimal		moderate		intense

---

2. Rate the level of **stress** experienced during the entire day.

1	2	3	4	5
minimal		moderate		intense

---

3. Rate the **mental effort** required to detect blunders.

1	2	3	4	5
minimal		moderate		intense

---

4. Rate the **mental effort** required to resolve blunders.

1	2	3	4	5
minimal		moderate		intense

---

5. Rate the level of **mental effort** required during the entire day.

1	2	3	4	5
minimal		moderate		intense

---

6. Rate the level of **activity** required during the entire day.

1	2	3	4	5
minimal		moderate		intense

---

7. Please comment on any occurrences/issues throughout the day, for example problems with visuals, communications, aircraft performance, long delays, pilot response, and other outside factors that may have affected your work environment.

Thank you for your cooperation with completing this questionnaire.

DEFINITIONS

The following list provides you with a guideline for each of the measures used in the Controller Questionnaire.

<u>STRESS</u>: (anxiety, frustration, pressure)

- Experienced to re-establish separation during a blunder
- Experienced when working with the PRM system
- Experienced in remaining alert

<u>MENTAL EFFORT</u>: (concentration, attention, decision-making)

- Experienced in trying to maintain vigilance
- Attention involved in detecting and resolving blunders
- Experienced because of the equipment

<u>ACTIVITY</u>: (frequency of actions, time spent on tasks)

- Workload
- Number of blunders
- Traffic density

POST-SIMULATION CONTROLLER QUESTIONNAIRE

October 16-27, 1995

NOTE: All responses provided from the following questionnaire will be reported as an aggregate. Individual responses will not be reported. To ensure complete anonymity, please do not write your name or controller letter on questionnaire. Thank you.

POST-SIMULATION CONTROLLER QUESTIONNAIRE

October 16-27, 1995

Please complete the following questionnaire based upon your experiences throughout the simulation. If you need additional space, use the back of the sheet. Should you have any questions, ask the SRC representative.

===

1. Dual simultaneous ILS approaches to runways spaced 3000 ft apart with one localizer offset by 2.5 degrees can be safely conducted as simulated. Explain.

1	2	3
Yes	No	Don't Know

____

____

____

____

____

____

===

1b. What improvements could be incorporated into the procedures, if any?

____

____

____

____

____

____

2. Assess the communications workload for NTZ entries and breakouts relative to current operations. Please explain.

1	2	3	4	5
Much less than current operations	Less than	Equal to	Greater than	Much greater than current operations

3. What specific control strategy, if any, did you develop for the simulated approach operation (e.g., inter-controller coordination, display scanning techniques)?

3b. Would these strategies be specific to this operation?

1	2	3
Yes	No	Don't Know

===

4. Assess the adequacy of the briefing information and training aids (e.g., video, training booklet) you were given prior to working the monitor position.

5. Rate the realism of the traffic (e.g., aircraft types, density). Please explain.

1	2	3	4	5
Low		Moderate		High

____

____

____

____

____

____

____

____

==

6. Were there any cues that you used to anticipate the occurrence of blunders? Please describe.

1	2	3
Yes	No	Don't Know

____

____

____

____

____

____

____

____

7. Please describe any items in the simulation which you believe were not realistic or whose realism could have been improved upon (include any comments about equipment, displays, communication, etc.).

8. Additional comments:

Thank you for participating in this simulation!

Appendix J

Flight Simulator Pilot Questionnaires

PILOT BREAK-OUT QUESTIONNAIRE

(WRITE IN ANSWERS IN THE "Q" COLUMNS ON COORDINATORS' LOG)

October 16 - 27, 1995

Q1. WAS THE BREAK-OUT INSTRUCTION COMMUNICATED CLEARLY AND CONCISELY? (E.G., RATE OF SPEECH, CLARITY, VOLUME, ETC.)

PUT "Y" OR "N" IN BLOCK "Q1"

IF NO, STATE REASON IN THE COMMENTS SECTION.

Q2. IN WHAT ORDER WAS THE BREAK-OUT INSTRUCTION GIVEN AND HOW MANY TRANSMISSIONS DID IT TAKE FOR THE INITIAL INSTRUCTIONS?

1 - HEADING, ALTITUDE (IN ONE TRANSMISSION)

2 - ALTITUDE, HEADING (IN ONE TRANSMISSION)

3 - HEADING, ALTITUDE (IN TWO SEPARATE TRANSMISSIONS)

4 - ALTITUDE, HEADING (IN TWO SEPARATE TRANSMISSIONS)

5 - OTHER

IF 5 - OTHER, PLEASE DESCRIBE IN THE COMMENTS SECTION.

Q3. DID THE CONTROLLER GIVE YOU MORE THAN ONE TURN?

1 - ONE TURN.   2 - TWO OR MORE INCREMENT TURNS

Q4. GIVEN THE CONTROLLER INSTRUCTION, AIRCRAFT CONFIGURATION, AND FLIGHT REGIME, RATE THE DIFFICULTY OF THE BREAK-OUT MANEUVER.

1	2	3	4	5
NOT DIFFICULT				VERY DIFFICULT

IF DIFFICULT WRITE REASONS IN COMMENTS SECTION

Q5. DID THE BREAKOUT INSTRUCTIONS BEGIN WITH "TRAFFIC ALERT"?

PUT "Y" OR "N" IN BLOCK "Q5"

Q6. WHAT, IF ANY, ADDITIONAL COMMENTS DO YOU HAVE?

WRITE THEM IN THE COMMENTS SECTION

FLIGHT CREW OPINION SURVEY

October 16 - 27, 1995

DATE: ______________________ PILOT CODE: ___________

TOTAL FLIGHT HOURS_________

HOURS IN TYPE_______________

LAST TIME IN A SIMULATOR (mo/yr)____________

SITE: AVIA GAT MD90 NASA OK CITY

Please circle the appropriate response for all of the following questions, and provide feedback on the lines provided. If necessary, continue feedback on the back of the page. If you have any questions, consult your Site Coordinator.

===

1. Based on the information presented on your approach plates and airport information page, in combination with the simulated weather conditions, how would you choose to fly close parallel approaches?

(1) Coupled Autopilot (2) Flight Director (3) Raw Data

Comments:

____

2. The <u>Airport Information Page</u> increased my awareness of possible traffic in close proximity on the adjacent approach.

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

Comments:

____

____

3. More crew coordination is required for simultaneous close parallel approaches than for normal ILS approaches.

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

Comments:

____

____

4. The <u>Airport Information Page</u> increased my awareness of simultaneous close parallel approach procedures.

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

Comments:

____

____

5. The new ATC phraseology ("Traffic Alert") coupled with the word "immediately" encouraged me to respond <u>more quickly</u> to the breakout maneuver than I would have if only the word "immediately" were used.

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

Comments:

____

____

6. The video increased my awareness of simultaneous close parallel approach operations.

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

Comments:

____

____

7. The training bulletins (Pilot Awareness and Procedure-if applicable) increased my understanding of what is expected of me during simultaneous close parallel approaches.

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

Comments:

____

____

8. What additional items would you like to see on the close parallel simultaneous approach plates?

____

____

9. What additional information would you like to see on the Airport Information Page?

____

____

10. The training bulletins helped me to execute the ATC-directed breakouts.

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

Comments:

____

____

11. What additional information or training would you like to have for simultaneous close parallel approach procedures?

____

____

12. In your estimation, based on your experience, what percentage of ILS approaches are flown on autopilot to Category I minima during IMC in normal line operations for:

(a) Glass Cockpit:

(1) 0 - 25 (2) 26 - 50 (3) 51 - 75 (4) 76 - 100 (5) Don't Know

(b) Conventional:

(1) 0 - 25 (2) 26 - 50 (3) 51 - 75 (4) 76 - 100 (5) Don't Know

Comments:

____

____

____

13. The no descending breakout altitude shown on the approach plate helped me better prepare for the possible breakout maneuver.

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

Comments:

____

____

____

14. Please list the importance (from 1 to 10) of each of the following items to a pilot flying a close parallel simultaneous approach. 1=Not Important, 10=Very Important

Item	Rating 1 to 10
Video	
Airport Information Page	
Separate Approach Plate for Close Parallel Simultaneous Approaches	
Notes in box on Approach Plate	
Pilot Awareness Bulletin	
Breakout Procedure Bulletin (MD - 90 / B - 747 - 400 ONLY)	
The use of words "Traffic Alert" in the breakout instruction	
No descending breakout altitude printed on approach plate	

15. Additional comments on the simulation or on the tested procedure.

Thank you for completing this survey and participating in the simulation. If you would like to have a copy of the final test report sent to you, please complete the form on the next page.

Appendix K

Observer Logs

TECHNICAL OBSERVER LOG

OBSERVER: RUN#: CONTROLLERS:

DATE: TRAFFIC SAMPLE: (18R) (18L)

SIM TIME	TCV	BLUNDER ID	RWY	EVADER ID	RWY	NBO	NTZ	Slow Turn Rate (P/A)	Slow Response Time (P/C/A)	Wrong Call Sign (P/C)	Instructions Not Followed	Other Factor

Additional Comments:

SIM TIME	TCV	BLUNDER ID	RWY	EVADER ID	RWY	NBO	NTZ	Slow Turn Rate (P/A)	Slow Response Time (P/C/A)	Wrong Call Sign (P/C)	Instructions Not Followed	Other Factor

Additional Comments:

SIM TIME	TCV	BLUNDER ID	RWY	EVADER ID	RWY	NBO	NTZ	Slow Turn Rate (P/A)	Slow Response Time (P/C/A)	Wrong Call Sign (P/C)	Instructions Not Followed	Other Factor

Additional Comments:

SIM TIME	TCV	BLUNDER ID	RWY	EVADER ID	RWY	NBO	NTZ	Slow Turn Rate (P/A)	Slow Response Time (P/C/A)	Wrong Call Sign (P/C)	Instructions Not Followed	Other Factor

Additional Comments:

October 16-27, 1995

TECHNICAL OBSERVER LOG

OBSERVER: RUN#: CONTROLLERS:

DATE: TRAFFIC SAMPLE: (18R) (18L)

SIM TIME	TCV	BLUNDER ID	RWY	EVADER ID	RWY	NBO	NTZ	Slow Turn Rate (P/A)	Slow Response Time (P/C/A)	Wrong Call Sign (P/C)	Instructions Not Followed	Other Factor
Additional Comments:												

SIM TIME	TCV	BLUNDER ID	RWY	EVADER ID	RWY	NBO	NTZ	Slow Turn Rate (P/A)	Slow Response Time (P/C/A)	Wrong Call Sign (P/C)	Instructions Not Followed	Other Factor
Additional Comments:												

SIM TIME	TCV	BLUNDER ID	RWY	EVADER ID	RWY	NBO	NTZ	Slow Turn Rate (P/A)	Slow Response Time (P/C/A)	Wrong Call Sign (P/C)	Instructions Not Followed	Other Factor
Additional Comments:												

SIM TIME	TCV	BLUNDER ID	RWY	EVADER ID	RWY	NBO	NTZ	Slow Turn Rate (P/A)	Slow Response Time (P/C/A)	Wrong Call Sign (P/C)	Instructions Not Followed	Other Factor
Additional Comments:												

October 16-27, 1995

Appendix L

Aircraft Performance Parameters

In addition to the pilot/aircraft response times in Section 11.6.4.2, maximum aircraft performance parameters were also extracted from the data collected at the flight simulator sites. The distribution of maximum bank angles achieved during the evasion maneuver is shown in Figure L-1. It should be noted that Figure L-1 does not indicate how long these bank angles were maintained. The data indicated that they were maintained anywhere from momentarily to several seconds.

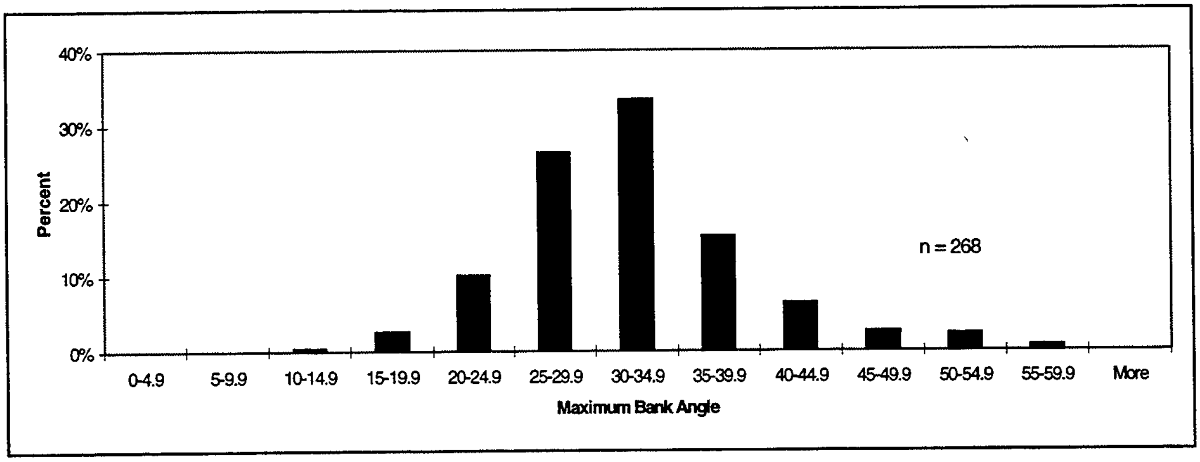


Figure L-1. Maximum Bank Angle During Evasion Maneuver

Other maximum aircraft performance parameters that were extracted included the average maximum roll rate (Figure L-2) and average maximum rate of climb (Figure L-3). "Average maximum" is the highest five-second average of roll rate or rate of climb during the evasion maneuver. The distributions include a sampling of at least 24 data points from each jet simulator site and all 15 data points from the GAT.

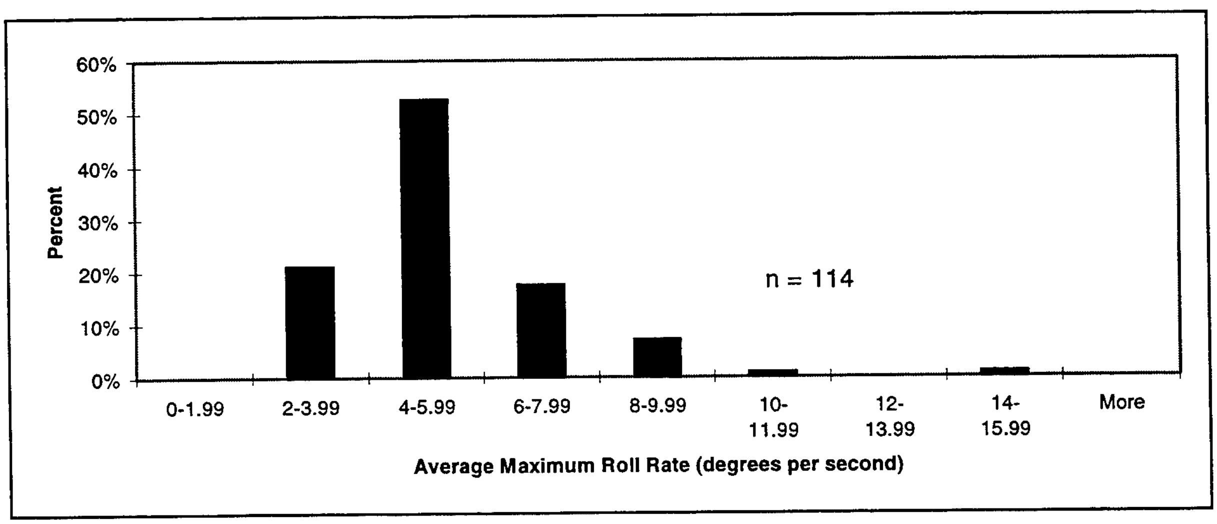


Figure L-2. Average Maximum Roll Rates During Evasion Maneuver

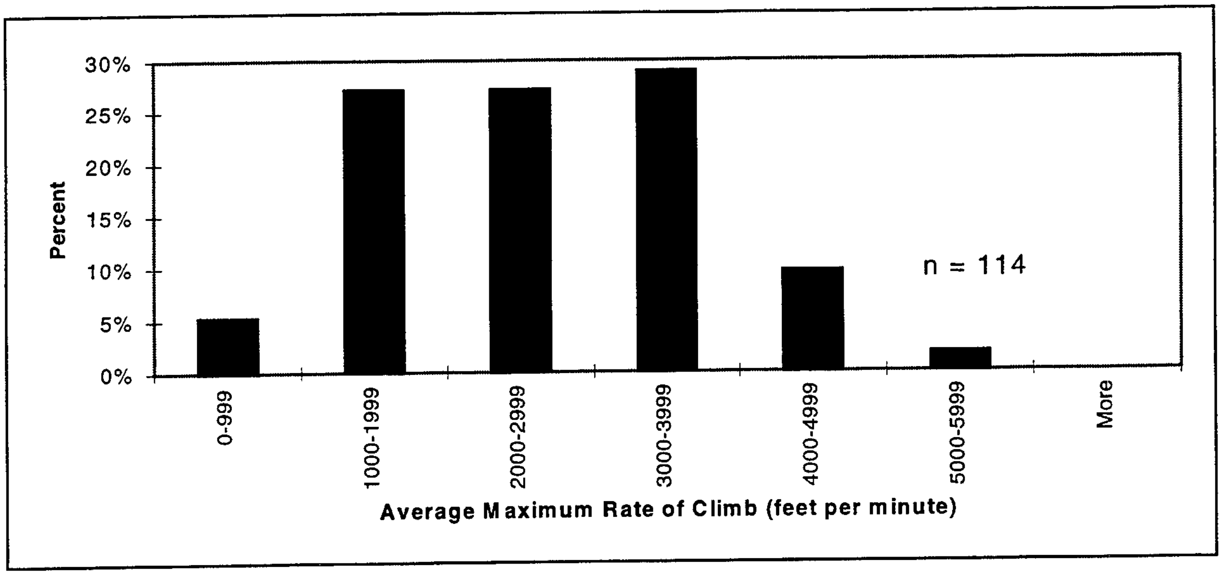


Figure L-3. Average Maximum Rates of Climb During Evasion Maneuver

Appendix M

Missed Approach Evaluation

In January 1996, FAA Standards Development Branch (AFS-450) conducted an evaluation of the missed approach to ILS Runway 22R at John F. Kennedy Airport (JFK), New York. The localizer course to JFK Runway 22R has a 2.5-degree offset from the runway centerline. The localizer offset creates a slightly converging approach and missed approach situation relative to Runway 22L, which is 3000 feet (ft) from Runway 22R. The objective of the evaluation was to acquire missed approach track data to determine the degree of safety and operational acceptability of conducting missed approaches with a 3-degree localizer offset to closely spaced parallel runways.

The evaluation utilized the FAA/NASA B747-400 flight simulator located at NASA Ames, San Jose, California. The flight crews flew missed approaches and landings as prescribed by the test director. The aircraft weight was set at 650,000 pounds to emulate the maximum landing weight and a decision height of 250 ft was used. Several flight parameters (x, y, and z, etc.) were recorded to document the crew/aircraft track performance. Prior to the simulator test session, each crew was briefed on the purpose of the test and after the simulator session a questionnaire was administered to each pilot.

The results of the evaluation were based on ten qualified B747-400 crews which flew a total of 78 missed approaches. The results are summarized as follows:

- Eight flight tracks of the 78 total missed approaches entered the NTZ.
- The mean lateral overshoot of the centerline was 334.3 ft with a standard deviation of 110.4 ft.
- The maximum lateral penetration of the NTZ was 205.3 ft.
- Flight track rotational analysis revealed that the NTZ penetrations during the missed approach were due to the 3-degree localizer offset.
- The pilot questionnaire revealed that the crews found the approaches and missed approaches with a 3-degree localizer offset and a 250 ft decision height very acceptable. The pilots made the following suggestions: crosswinds should be limited to 10 knots; autoland operations should not be allowed; and Air Traffic Control (ATC) should monitor the missed approach to give corrective action as needed.

From the test results, it can be concluded that if a near gaussion distribution is assumed for the missed approach tracks, approximately seven percent of the missed approaches would enter the NTZ. Therefore, ATC monitoring of the missed approach should be required to insure adequate separation in the event of a simultaneous missed approach on parallel runways spaced 3000 ft apart with a localizer offset up to 3 degrees.

Additional evaluation was accomplished by AFS-450 with the Airspace Simulation and Analysis for TERPS (ASAT) computer model. Computer software was developed to characterize the JFK airport which included the approaches and missed approaches for Runway 22L and 22R. Runway 22R has a 2.5-degree localizer offset. In this evaluation, approaches and missed approaches were performed with a 50 percent mix of B727 and B747 aircraft. The missed approach procedure was performed as per the Jeppesen charts, as follows:

Runway 22L: Climb to 500 feet, then climbing left turn to 3000 ft via JFK R-190 to CHANT Int/19 DME and hold.

Runway 22R: Climb to 4000 ft direct COL VOR/DME and hold.

The operational procedure of the two aircraft types was as follows:

	B727	B747
Approach (Kts)	130-138	135-140
Climb (Kts)	185-200	200-230
Climb at ROC (Fpm)	1500	1500

Test parameters were varied from run to run based on pre-defined distributions and/or pre-defined ranges. The following parameters were varied:

- Aircraft type on each runway
- Missed approach distance from runway threshold
- Lateral and vertical distance from ILS centerline
- Height loss induced by aircraft load factor
- Altitude at which the aircraft going around on Runway 22L starts turning to heading

The ASAT system performed 10,000 Monte Carlo type simulations of the approaches and missed approaches to Runways 22L and 22R at JFK airport. The specified operational parameters were varied within normal ranges and no blunder scenarios were tested. The results of this evaluation are as follows:

- During the missed approach, the closest point between the center of the two aircraft targets was approximately 1950 ft.
- The maximum lateral penetration of the NTZ was approximately 200 ft for Runway 22R with a 2.5-degree localizer offset.

The results of the ASAT evaluation, like the B747-400 test, revealed that penetration of the NTZ between the runways can be expected. ATC monitoring of the missed approach should be required to insure separation in the event of a simultaneous missed approach.